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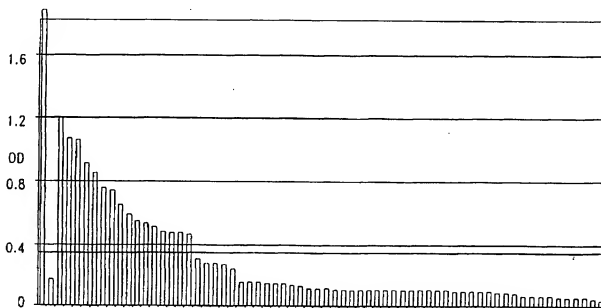
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(54) Title: COMPOSITIONS AND METHODS FOR WT1 SPECIFIC IMMUNOTHERAPY



(57) Abstract: Compositions and methods for the therapy of malignant diseases, such as leukemia and cancer, are disclosed. The compositions comprise one or more of a WT1 polynucleotide, a WT1 polypeptide, an antigen-presenting cell presenting a WT1 polypeptide, an antibody that specifically binds to a WT1 polypeptide; or a T cell that specifically reacts with a WT1 polypeptide. Such compositions may be used, for example, for the prevention and treatment of metastatic diseases.

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COMPOSITIONS AND METHODS FOR WT1 SPECIFIC IMMUNOTHERAPY

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

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- 5 NIH SBIR Phase I grant number IR43 CA81752-01A1. The Government may have certain rights in this invention.

BACKGROUND OF THE INVENTION

Field of the Invention

- The present invention relates generally to the immunotherapy of
- 10 malignant diseases such as leukemia and cancers. The invention is more specifically related to compositions for generating or enhancing an immune response to WT1, and to the use of such compositions for preventing and/or treating malignant diseases.

Description of the Related Art

- 15 Cancer and leukemia are significant health problems in the United States and throughout the world. Although advances have been made in detection and treatment of such diseases, no vaccine or other universally successful method for prevention or treatment of cancer and leukemia is currently available. Management of the diseases currently relies on a
- 20 combination of early diagnosis and aggressive treatment, which may include one or more of a variety of treatments such as surgery, radiotherapy, chemotherapy and hormone therapy. The course of treatment for a particular cancer is often selected based on a variety of prognostic parameters, including an analysis of specific tumor markers. However, the use of established
- 25 markers often leads to a result that is difficult to interpret, and the high mortality continues to be observed in many cancer patients.

Immunotherapies have the potential to substantially improve cancer and leukemia treatment and survival. Recent data demonstrate that

- leukemia can be cured by immunotherapy in the context of bone marrow transplantation (e.g., donor lymphocyte infusions). Such therapies may involve the generation or enhancement of an immune response to a tumor-associated antigen (TAA). However, to date relatively few TAAs are known and the
- 5 generation of an immune response against such antigens has, with rare exception, not been shown to be therapeutically beneficial.

Accordingly, there is a need in the art for improved methods for leukemia and cancer prevention and therapy. The present invention fulfills these needs and further provides other related advantages.

10 BRIEF SUMMARY OF THE INVENTION

- Briefly stated, this invention provides compositions and methods for the diagnosis and therapy of diseases such as leukemia and cancer. In one aspect, the present invention provides polypeptides comprising an immunogenic portion of a native WT1, or a variant thereof that differs in one
- 15 more substitutions, deletions, additions and/or insertions such that the ability of the variant to react with antigen-specific antisera and/or T-cell lines or clones is not substantially diminished. Within certain embodiments of the present invention, the polypeptide comprises at least an immunogenic portion of WT1 wherein the immunogenic portion is contained within amino acids 2-281 of
- 20 WT1. Within certain embodiments, the polypeptide comprises no more than 16 consecutive amino acid residues of a native WT1 polypeptide. Within other embodiments, the polypeptide comprises an immunogenic portion of amino acid residues 1 - 174 of a native WT1 polypeptide or a variant thereof, wherein the polypeptide comprises no more than 16 consecutive amino acid residues
- 25 present within amino acids 175 to 449 of the native WT1 polypeptide. The immunogenic portion preferably binds to an MHC class I and/or class II molecule. Within certain embodiments, the polypeptide comprises a sequence selected from the group consisting of (a) sequences recited in any one or more of Tables II - XLVI, (b) variants of the foregoing sequences that differ in one or
- 30 more substitutions, deletions, additions and/or insertions such that the ability of

the variant to react with antigen-specific antisera and/or T-cell lines or clones is not substantially diminished and (c) mimetics of the polypeptides recited above, such that the ability of the mimetic to react with antigen-specific antisera and/or T cell lines or clones is not substantially diminished.

- 5 Within other embodiments, the polypeptide comprises a sequence selected from the group consisting of (a) ALLPAVPSL (SEQ ID NO:34), GATLKGVA (SEQ ID NO:88), CMTWNQMNL (SEQ ID NOs: 49 and 258), SCLESQPTI (SEQ ID NOs: 199 and 296), SCLESQPAI (SEQ ID NO:198), NLYQMTSQL (SEQ ID NOs: 147 and 284), ALLPAVSSL (SEQ ID NOs: 35 and 255), RMFPNAPYL (SEQ ID NOs: 185 and 293), VLDFAPPGA (SEQ ID NO:241), VLDFAPPGAS (SEQ ID NO:411), SEQ ID NOs: 414-450, ALLPAVPSL (SEQ ID NO:451) (b) variants of the foregoing sequences that differ in one or more substitutions, deletions, additions and/or insertions such that the ability of the variant to react with antigen-specific antisera and/or T-cell
- 10 lines or clones is not substantially diminished and (c) mimetics of the polypeptides recited above, such that the ability of the mimetic to react with antigen-specific antisera and/or T cell lines or clones is not substantially diminished. Mimetics may comprises amino acids in combination with one or more amino acid mimetics or may be entirely nonpeptide mimetics.

- 15 Within further aspects, the present invention provides polypeptides comprising a variant of an immunogenic portion of a WT1 protein, wherein the variant differs from the immunogenic portion due to substitutions at between 1 and 3 amino acid positions within the immunogenic portion such that the ability of the variant to react with antigen-specific antisera and/or T-cell lines
- 20 or clones is not substantially reduced or is enhanced relative to a native WT1 protein.

The present invention further provides WT1 polynucleotides that encode a WT1 polypeptide as described above.

- 25 Within other aspects, the present invention provides pharmaceutical compositions and vaccines. Pharmaceutical compositions may comprise a polypeptide or mimetic as described above and/or one or more of (i)
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a WT1 polynucleotide; (ii) an antibody or antigen-binding fragment thereof that specifically binds to a WT1 polypeptide; (iii) a T cell that specifically reacts with a WT1 polypeptide or (iv) an antigen-presenting cell that expresses a WT1 polypeptide, in combination with a pharmaceutically acceptable carrier or
5 excipient. Vaccines comprise a polypeptide as described above and/or one or more of (i) a WT1 polynucleotide, (ii) an antigen-presenting cell that expresses a WT1 polypeptide or (iii) an anti-idiotypic antibody, and a non-specific immune response enhancer. Within certain embodiments, less than 23 consecutive amino acid residues, preferably less than 17 amino acid residues, of a native
10 WT1 polypeptide are present within a WT1 polypeptide employed within such pharmaceutical compositions and vaccines. The immune response enhancer may be an adjuvant. Preferably, an immune response enhancer enhances a T cell response.

The present invention further provides methods for enhancing or
15 inducing an immune response in a patient, comprising administering to a patient a pharmaceutical composition or vaccine as described above. In certain embodiments, the patient is a human.

The present invention further provides methods for inhibiting the development of a malignant disease in a patient, comprising administering to a
20 patient a pharmaceutical composition or vaccine as described above. Malignant diseases include, but are not limited to leukemias (e.g., acute myeloid, acute lymphocytic and chronic myeloid) and cancers (e.g., breast, lung, thyroid or gastrointestinal cancer or a melanoma). The patient may, but need not, be afflicted with the malignant disease, and the administration of the
25 pharmaceutical composition or vaccine may inhibit the onset of such a disease, or may inhibit progression and/or metastasis of an existing disease.

The present invention further provides, within other aspects, methods for removing cells expressing WT1 from bone marrow and/or peripheral blood or fractions thereof, comprising contacting bone marrow,
30 peripheral blood or a fraction of bone marrow or peripheral blood with T cells that specifically react with a WT1 polypeptide, wherein the step of contacting is

- performed under conditions and for a time sufficient to permit the removal of WT1 positive cells to less than 10%, preferably less than 5% and more preferably less than 1%, of the number of myeloid or lymphatic cells in the bone marrow, peripheral blood or fraction. Bone marrow, peripheral blood and
- 5 fractions may be obtained from a patient afflicted with a disease associated with WT1 expression, or may be obtained from a human or non-human mammal not afflicted with such a disease.

Within related aspects, the present invention provides methods for inhibiting the development of a malignant disease in a patient, comprising

10 administering to a patient bone marrow, peripheral blood or a fraction of bone marrow or peripheral blood prepared as described above. Such bone marrow, peripheral blood or fractions may be autologous, or may be derived from a related or unrelated human or non-human animal (e.g., syngeneic or allogeneic).

- 15 In other aspects, the present invention provides methods for stimulating (or priming) and/or expanding T cells, comprising contacting T cells with a WT1 polypeptide under conditions and for a time sufficient to permit the stimulation and/or expansion of T cells. Such T cells may be autologous, allogeneic, syngeneic or unrelated WT1-specific T cells, and may be stimulated
- 20 *in vitro* or *in vivo*. Expanded T cells may, within certain embodiments, be present within bone marrow, peripheral blood or a fraction of bone marrow or peripheral blood, and may (but need not) be clonal. Within certain embodiments, T cells may be present in a mammal during stimulation and/or expansion. WT1-specific T cells may be used, for example, within donor
- 25 lymphocyte infusions.

Within related aspects, methods are provided for inhibiting the development of a malignant disease in a patient, comprising administering to a patient T cells prepared as described above. Such T cells may, within certain embodiments, be autologous, syngeneic or allogeneic.

- 30 The present invention further provides, within other aspects, methods for monitoring the effectiveness of an immunization or therapy for a

- malignant disease associated with WT1 expression in a patient. Such methods are based on monitoring antibody, CD4+ T cell and/or CD8+ T cell responses in the patient. Within certain such aspects, a method may comprise the steps of: (a) incubating a first biological sample with one or more of: (i) a WT1
- 5 polypeptide; (ii) a polynucleotide encoding a WT1 polypeptide; or (iii) an antigen presenting cell that expresses a WT1 polypeptide, wherein the first biological sample is obtained from a patient prior to a therapy or immunization, and wherein the incubation is performed under conditions and for a time sufficient to allow immunocomplexes to form; (b) detecting immunocomplexes
- 10 formed between the WT1 polypeptide and antibodies in the biological sample that specifically bind to the WT1 polypeptide; (c) repeating steps (a) and (b) using a second biological sample obtained from the same patient following therapy or immunization; and (d) comparing the number of immunocomplexes detected in the first and second biological samples, and therefrom monitoring
- 15 the effectiveness of the therapy or immunization in the patient.

Within certain embodiments of the above methods, the step of detecting comprises (a) incubating the immunocomplexes with a detection reagent that is capable of binding to the immunocomplexes, wherein the detection reagent comprises a reporter group, (b) removing unbound detection

20 reagent, and (c) detecting the presence or absence of the reporter group. The detection reagent may comprise, for example, a second antibody, or antigen-binding fragment thereof, capable of binding to the antibodies that specifically bind to the WT1 polypeptide or a molecule such as Protein A. Within other embodiments, a reporter group is bound to the WT1 polypeptide, and the step

25 of detecting comprises removing unbound WT1 polypeptide and subsequently detecting the presence or absence of the reporter group.

Within further aspects, methods for monitoring the effectiveness of an immunization or therapy for a malignant disease associated with WT1 expression in a patient may comprise the steps of: (a) incubating a first

30 biological sample with one or more of: (i) a WT1 polypeptide; (ii) a polynucleotide encoding a WT1 polypeptide; or (iii) an antigen presenting cell

- that expresses a WT1 polypeptide, wherein the biological sample comprises CD4+ and/or CD8+ T cells and is obtained from a patient prior to a therapy or immunization, and wherein the incubation is performed under conditions and for a time sufficient to allow specific activation, proliferation and/or lysis of T cells; (b) detecting an amount of activation, proliferation and/or lysis of the T cells; (c) repeating steps (a) and (b) using a second biological sample comprising CD4+ and/or CD8+ T cells, wherein the second biological sample is obtained from the same patient following therapy or immunization; and (d) comparing the amount of activation, proliferation and/or lysis of T cells in the first and second biological samples, and therefrom monitoring the effectiveness of the therapy or immunization in the patient.

- The present invention further provides methods for inhibiting the development of a malignant disease associated with WT1 expression in a patient, comprising the steps of: (a) incubating CD4+ and/or CD8+ T cells isolated from a patient with one or more of: (i) a WT1 polypeptide; (ii) a polynucleotide encoding a WT1 polypeptide; or (iii) an antigen presenting cell that expresses a WT1 polypeptide, such that the T cells proliferate; and (b) administering to the patient an effective amount of the proliferated T cells, and therefrom inhibiting the development of a malignant disease in the patient.
- Within certain embodiments, the step of incubating the T cells may be repeated one or more times.

- Within other aspects, the present invention provides methods for inhibiting the development of a malignant disease associated with WT1 expression in a patient, comprising the steps of: (a) incubating CD4+ and/or CD8+ T cells isolated from a patient with one or more of: (i) a WT1 polypeptide; (ii) a polynucleotide encoding a WT1 polypeptide; or (iii) an antigen presenting cell that expresses a WT1 polypeptide, such that the T cells proliferate; (b) cloning one or more cells that proliferated; and (c) administering to the patient an effective amount of the cloned T cells.

- Within other aspects, methods are provided for determining the presence or absence of a malignant disease associated with WT1 expression

- in a patient, comprising the steps of: (a) incubating CD4⁺ and/or CD8⁺ T cells isolated from a patient with one or more of: (i) a WT1 polypeptide; (ii) a polynucleotide encoding a WT1 polypeptide; or (iii) an antigen presenting cell that expresses a WT1 polypeptide; and (b) detecting the presence or absence of specific activation of the T cells, therefrom determining the presence or absence of a malignant disease associated with WT1 expression. Within certain embodiments, the step of detecting comprises detecting the presence or absence of proliferation of the T cells.

- Within further aspects, the present invention provides methods for determining the presence or absence of a malignant disease associated with WT1 expression in a patient, comprising the steps of: (a) incubating a biological sample obtained from a patient with one or more of: (i) a WT1 polypeptide; (ii) a polynucleotide encoding a WT1 polypeptide; or (iii) an antigen presenting cell that expresses a WT1 polypeptide, wherein the incubation is performed under conditions and for a time sufficient to allow immunocomplexes to form; and (b) detecting immunocomplexes formed between the WT1 polypeptide and antibodies in the biological sample that specifically bind to the WT1 polypeptide; and therefrom determining the presence or absence of a malignant disease associated with WT1 expression.

- These and other aspects of the present invention will become apparent upon reference to the following detailed description and attached drawings. All references disclosed herein are hereby incorporated by reference in their entirety as if each was incorporated individually.

BRIEF DESCRIPTION OF THE DRAWINGS

- Figure 1 depicts a comparison of the mouse (MO) and human (HU) WT1 protein sequences (SEQ ID NOS: 320 and 319 respectively).

- Figure 2 is a Western blot illustrating the detection of WT1 specific antibodies in patients with hematological malignancy (AML). Lane 1 shows molecular weight markers; lane 2 shows a positive control (WT1 positive human leukemia cell line immunoprecipitated with a WT1 specific antibody);

lane 3 shows a negative control (WT1 positive cell line immunoprecipitated with mouse sera); and lane 4 shows a WT1 positive cell line immunoprecipitated with sera of a patient with AML. For lanes 2-4, the immunoprecipitate was separated by gel electrophoresis and probed with a WT1 specific antibody.

- 5 Figure 3 is a Western blot illustrating the detection of a WT1 specific antibody response in B6 mice immunized with TRAMP-C, a WT1 positive tumor cell line. Lanes 1, 3 and 5 show molecular weight markers, and lanes 2, 4 and 6 show a WT1 specific positive control (N180, Santa Cruz Biotechnology, polypeptide spanning 180 amino acids of the N-terminal region of the WT1 protein, migrating on the Western blot at 52 kD). The primary antibody used was WT180 in lane 2, sera of non-immunized B6 mice in lane 4 and sera of the immunized B6 mice in lane 6.

- Figure 4 is a Western blot illustrating the detection of WT1 specific antibodies in mice immunized with representative WT1 peptides.
- 15 Lanes 1, 3 and 5 show molecular weight markers and lanes 2, 4 and 6 show a WT1 specific positive control (N180, Santa Cruz Biotechnology, polypeptide spanning 180 amino acids of the N-terminal region of the WT1 protein, migrating on the Western blot at 52 kD). The primary antibody used was WT180 in lane 2, sera of non-immunized B6 mice in lane 4 and sera of the immunized B6 mice in lane 6.
- 20

- Figures 5A to 5C are graphs illustrating the stimulation of proliferative T cell responses in mice immunized with representative WT1 peptides. Thymidine incorporation assays were performed using one T cell line and two different clones, as indicated, and results were expressed as cpm.
- 25 Controls indicated on the x axis were no antigen (No Ag) and B6/media; antigens used were p6-22 human (p1), p117-139 (p2) or p244-262 human (p3).

- Figure 6A and 6B are histograms illustrating the stimulation of proliferative T cell responses in mice immunized with representative WT1 peptides. Three weeks after the third immunization, spleen cells of mice that had been inoculated with Vaccine A or Vaccine B were cultured with medium alone (medium) or spleen cells and medium (B6/no antigen), B6 spleen cells
- 30

pulsed with the peptides p6-22 (p6), p117-139 (p117), p244-262 (p244) (Vaccine A; Figure 6A) or p287-301 (p287), p299-313 (p299), p421-435 (p421) (Vaccine B; Figure 6B) and spleen cells pulsed with an irrelevant control peptide (irrelevant peptide) at 25ug/ml and were assayed after 96hr for proliferation by (^3H) thymidine incorporation. Bars represent the stimulation index (SI), which is calculated as the mean of the experimental wells divided by the mean of the control (B6 spleen cells with no antigen).

Figures 7A-7D are histograms illustrating the generation of proliferative T-cell lines and clones specific for p117-139 and p6-22. Following *in vivo* immunization, the initial three *in vitro* stimulations (IVS) were carried out using all three peptides of Vaccine A or B, respectively. Subsequent IVS were carried out as single peptide stimulations using only the two relevant peptides p117-139 and p6-22. Clones were derived from both the p6-22 and p117-139 specific T cell lines, as indicated. T cells were cultured with medium alone (medium) or spleen cells and medium (B6/no antigen), B6 spleen cells pulsed with the peptides p6-22 (p6), p117-139 (p117) or an irrelevant control peptide (irrelevant peptide) at 25ug/ml and were assayed after 96hr for proliferation by (^3H) thymidine incorporation. Bars represent the stimulation index (SI), which is calculated as the mean of the experimental wells divided by the mean of the control (B6 spleen cells with no antigen).

Figures 8A and 8B present the results of TSITES Analysis of human WT1 (SEQ ID NO:319) for peptides that have the potential to elicit Th responses. Regions indicated by "A" are AMPHI midpoints of blocks, "R" indicates residues matching the Rothbard/Taylor motif, "D" indicates residues matching the IAd motif, and "d" indicates residues matching the IEd motif.

Figures 9A and 9B are graphs illustrating the elicitation of WT1 peptide-specific CTL in mice immunized with WT1 peptides. Figure 9A illustrates the lysis of target cells by allogeneic cell lines and Figure 9B shows the lysis of peptide coated cell lines. In each case, the % lysis (as determined by standard chromium release assays) is shown at three indicated effector:target ratios. Results are provided for lymphoma cells (LSTRA and

E10), as well as E10 + p235-243 (E10+P235). E10 cells are also referred to herein as EL-4 cells.

Figures 10A-10D are graphs illustrating the elicitation of WT1 specific CTL, which kill WT1 positive tumor cell lines but do not kill WT1 negative cell lines, following vaccination of B6 mice with WT1 peptide P117. Figure 10A illustrates that T-cells of non-immunized B6 mice do not kill WT1 positive tumor cell lines. Figure 10B illustrates the lysis of the target cells by allogeneic cell lines. Figures 10C and 10D demonstrate the lysis of WT1 positive tumor cell lines, as compared to WT1 negative cell lines in two different experiments. In addition, Figures 10C and 10D show the lysis of peptide-coated cell lines (WT1 negative cell line E10 coated with the relevant WT1 peptide P117). In each case, the % lysis (as determined by standard chromium release assays) is shown at three indicated effector:target ratios. Results are provided for lymphoma cells (E10), prostate cancer cells (TRAMP-C), a transformed fibroblast cell line (BLK-SV40), as well as E10+p117.

Figures 11A and 11B are histograms illustrating the ability of representative peptide P117-139 specific CTL to lyse WT1 positive tumor cells. Three weeks after the third immunization, spleen cells of mice that had been inoculated with the peptides p235-243 or p117-139 were stimulated *in vitro* with the relevant peptide and tested for ability to lyse targets incubated with WT1 peptides as well as WT1 positive and negative tumor cells. The bars represent the mean % specific lysis in chromium release assays performed in triplicate with an E:T ratio of 25:1. Figure 11A shows the cytotoxic activity of the p235-243 specific T cell line against the WT1 negative cell line EL-4 (EL-4, WT1 negative); EL-4 pulsed with the relevant (used for immunization as well as for restimulation) peptide p235-243 (EL-4+p235); EL-4 pulsed with the irrelevant peptides p117-139 (EL-4+p117), p126-134 (EL-4+p126) or p130-138 (EL-4+p130) and the WT1 positive tumor cells BLK-SV40 (BLK-SV40, WT1 positive) and TRAMP-C (TRAMP-C, WT1 positive), as indicated. Figure 11B shows cytotoxic activity of the p117-139 specific T cell line against EL-4; EL-4 pulsed with the relevant peptide P117-139 (EL-4+p117) and EL-4 pulsed with

the irrelevant peptides p123-131 (EL-4+p123), or p128-136 (EL-4+p128); BLK-SV40 and TRAMP-C, as indicated.

Figures 12A and 12B are histograms illustrating the specificity of lysis of WT1 positive tumor cells, as demonstrated by cold target inhibition.

- 5 The bars represent the mean % specific lysis in chromium release assays performed in triplicate with an E:T ratio of 25:1. Figure 12A shows the cytotoxic activity of the p117-139 specific T cell line against the WT1 negative cell line EL-4 (EL-4, WT1 negative); the WT1 positive tumor cell line TRAMP-C (TRAMP-C, WT1 positive); TRAMP-C cells incubated with a ten-fold excess (compared to the hot target) of EL-4 cells pulsed with the relevant peptide p117-139 (TRAMP-C + p117 cold target) without ⁵¹Cr labeling and TRAMP-C cells incubated with EL-4 pulsed with an irrelevant peptide without ⁵¹Cr labeling (TRAMP-C + irrelevant cold target), as indicated. Figure 12B shows the cytotoxic activity of the p117-139 specific T cell line against the WT1 negative cell line EL-4 (EL-4, WT1 negative); the WT1 positive tumor cell line BLK-SV40 (BLK-SV40, WT1 positive); BLK-SV40 cells incubated with the relevant cold target (BLK-SV40 + p117 cold target) and BLK-SV40 cells incubated with the irrelevant cold target (BLK-SV40 + irrelevant cold target), as indicated.
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- Figures 13A-13C are histograms depicting an evaluation of the 9mer CTL epitope within p117-139. The p117-139 tumor specific CTL line was tested against peptides within aa117-139 containing or lacking an appropriate H-2^b class I binding motif and following restimulation with p126-134 or p130-138. The bars represent the mean % specific lysis in chromium release assays performed in triplicate with an E:T ratio of 25:1. Figure 13A shows the cytotoxic activity of the p117-139 specific T cell line against the WT1 negative cell line EL-4 (EL-4, WT1 negative) and EL-4 cells pulsed with the peptides p117-139 (EL-4 + p117), p119-127 (EL-4 + p119), p120-128 (EL-4 + p120), p123-131 (EL-4 + p123), p126-134 (EL-4 + p126), p128-136 (EL-4 + p128), and p130-138 (EL-4 + p130). Figure 13B shows the cytotoxic activity of the CTL line after restimulation with p126-134 against the WT1 negative cell line EL-4, EL-4 cells pulsed with p117-139 (EL-4 + p117), p126-134 (EL-4 + p126) and the WT1
- 20
- 25
- 30

positive tumor cell line TRAMP-C. Figure 13C shows the cytotoxic activity of the CTL line after restimulation with p130-138 against EL-4, EL-4 cells pulsed with p117-139 (EL-4 + p117), p130-138 (EL-4 + p130) and the WT1 positive tumor cell line TRAMP-C.

5 Figure 14 depicts serum antibody reactivity to WT1 in 63 patients with AML. Reactivity of serum antibody to WT1/N-terminus protein was evaluated by ELISA in patients with AML. The first and second lanes represent the positive and negative controls, respectively. The first and second lanes represent the ositive and negative controls, respectively. Commercially
10 obtained WT1 specific antibody WT180 was used for the positive control. The next 63 lanes represent results using sera from each individual patient. The OD values depicted were from ELISA using a 1:500 serum dilution. The figure includes cumulative data from 3 separate experiments.

 Figure 15 depicts serum antibody reactivity to WT1 proteins and
15 control proteins in 2 patients with AML. Reactivity of serum antibody to WT1/full-length, WT1N-terminus, TRX and Ra12 proteins was evaluated by ELISA in 2 patients with AML. The OD values depicted were from ELISA using a 1:500 serum dilution. AML-1 and AML-2 denote serum from 2 of the individual patients in Figure 1 with demonstrated antibody reactivity to WT1/full-
20 length. The WT1 full-length protein was expressed as a fusion protein with Ra12. The WT1/N-terminus protein was expressed as a fusion protein with TRX. The control Ra12 and TRX proteins were purified in a similar manner. The results confirm that the serum antibody reactivity against the WT1 fusion proteins is directed against the WT1 portions of the protein.

25 Figure 16 depicts serum antibody reactivity to WT1 in 81 patients with CML. Reactivity of serum antibody to WT1/full-length protein was evaluated by ELISA in patients with AML. The first and second lanes represent the positive and negative controls, respectively. Commercially obtained WT1 specific antibody WT180 was used for the positive control. The next 81 lanes
30 represent results using sera from each individual patient. The OD values

depicted were from ELISA using a 1:500 serum dilution. The figure includes cumulative data from 3 separate experiments.

Figure 17 depicts serum antibody reactivity to WT1 proteins and control proteins in 2 patients with CML. Reactivity of serum antibody to WT1/full-length, WT1/N-terminus, TRX and Ra12 proteins was evaluated by ELISA in 2 patients with CML. The OD values depicted were from ELISA using a 1:500 serum dilution. CML-1 and CML-2 denote serum from 2 of the individual patients in Figure 3 with demonstrated antibody reactivity to WT1/full-length. The WT1/full-length protein was expressed as a fusion protein with Ra12. The WT1/N-terminus protein was expressed as a fusion protein with TRX. The control Ra12 and TRX proteins were purified in a similar manner. The results confirm that the serum antibody reactivity against the WT1 fusion proteins is directed against the WT1 portions of the protein.

Figure 18 provides the characteristics of the recombinant WT1 proteins used for serological analysis.

Figure 19A-19E is a bar graph depicting the antibody responses in mice elicited by vaccination with different doses of WT1 protein.

Figure 20 is a bar graph of the proliferative T-cell responses in mice immunized with WT1 protein.

Figure 21 is a photograph of human DC, examined by fluorescent microscopy, expressing WT1 following adeno WT1 and Vaccinia WT1 infection.

Figure 22 is a photograph that demonstrates that WT1 expression in human DC is reproducible following adeno WT1 infection and is not induced by a control Adeno infection.

Figure 23 is a graph of an IFN-gamma ELISPOT assay showing that WT1 whole gene *in vitro* priming elicits WT1 specific T-cell responses.

Figure 24 shows amino acids 2-281 (SEQ ID NO:461) of the WT1 protein and the cDNA encoding these amino acid residues (SEQ ID NO:460).

This truncated WT1 protein is referred to as WT1-F.

DETAILED DESCRIPTION OF THE INVENTION

U.S. patents, U.S. patent application publications, U.S. patent applications, foreign patents, foreign patent applications and non-patent publications referred to in this specification and/or listed in the Application Data Sheet, are incorporated herein by reference, in their entirety.

As noted above, the present invention is generally directed to compositions and methods for the immunotherapy and diagnosis of malignant diseases. The compositions described herein may include WT1 polypeptides, WT1 polynucleotides, antigen-presenting cells (APC, e.g., dendritic cells) that express a WT1 polypeptide, agents such as antibodies that bind to a WT1 polypeptide and/or immune system cells (e.g., T cells) specific for WT1. WT1 Polypeptides of the present invention generally comprise at least a portion of a Wilms Tumor gene product (WT1) or a variant thereof. Nucleic acid sequences of the subject invention generally comprise a DNA or RNA sequence that encodes all or a portion of such a polypeptide, or that is complementary to such a sequence. Antibodies are generally immune system proteins, or antigen-binding fragments thereof, that are capable of binding to a portion of a WT1 polypeptide. T cells that may be employed within such compositions are generally T cells (e.g., CD4⁺ and/or CD8⁺) that are specific for a WT1 polypeptide. Certain methods described herein further employ antigen-presenting cells that express a WT1 polypeptide as provided herein.

The present invention is based on the discovery that an immune response raised against a Wilms Tumor (WT) gene product (e.g., WT1) can provide prophylactic and/or therapeutic benefit for patients afflicted with malignant diseases characterized by increased WT1 gene expression. Such diseases include, but are not limited to, leukemias (e.g., acute myeloid leukemia (AML), chronic myeloid leukemia (CML), acute lymphocytic leukemia (ALL) and childhood ALL), as well as many cancers such as lung, breast, thyroid and gastrointestinal cancers and melanomas. The WT1 gene was originally identified and isolated on the basis of a cytogenetic deletion at chromosome 11p13 in patients with Wilms' tumor (see Call et al., U.S. Patent

No. 5,350,840). The gene consists of 10 exons and encodes a zinc finger transcription factor, and sequences of mouse and human WT1 proteins are provided in Figure 1 and SEQ ID NOS: 319 and 320.

WT1 Polypeptides

- 5 Within the context of the present invention, a WT1 polypeptide is a polypeptide that comprises at least an immunogenic portion of a native WT1 (*i.e.*, a WT1 protein expressed by an organism that is not genetically modified), or a variant thereof, as described herein. A WT1 polypeptide may be of any length, provided that it comprises at least an immunogenic portion of a native
- 10 protein or a variant thereof. In other words, a WT1 polypeptide may be an oligopeptide (*i.e.*, consisting of a relatively small number of amino acid residues, such as 8-10 residues, joined by peptide bonds), a full length WT1 protein (*e.g.*, present within a human or non-human animal, such as a mouse) or a polypeptide of intermediate size. Within certain embodiments, the use of
- 15 WT1 polypeptides that contain a small number of consecutive amino acid residues of a native WT1 polypeptide is preferred. Such polypeptides are preferred for certain uses in which the generation of a T cell response is desired. For example, such a WT1 polypeptide may contain less than 23, preferably no more than 18, and more preferably no more than 15 consecutive
- 20 amino acid residues, of a native WT1 polypeptide. Polypeptides comprising nine consecutive amino acid residues of a native WT1 polypeptide are generally suitable for such purposes. Additional sequences derived from the native protein and/or heterologous sequences may be present within any WT1 polypeptide, and such sequences may (but need not) possess further
- 25 immunogenic or antigenic properties. Polypeptides as provided herein may further be associated (covalently or noncovalently) with other polypeptide or non-polypeptide compounds.

 An "immunogenic portion," as used herein is a portion of a polypeptide that is recognized (*i.e.*, specifically bound) by a B-cell and/or T-cell

30 surface antigen receptor. Certain preferred immunogenic portions bind to an

- MHC class I or class II molecule. As used herein, an immunogenic portion is said to "bind to" an MHC class I or class II molecule if such binding is detectable using any assay known in the art. For example, the ability of a polypeptide to bind to MHC class I may be evaluated indirectly by monitoring the ability to promote incorporation of ^{125}I labeled $\beta 2$ -microglobulin ($\beta 2\text{m}$) into MHC class I/ $\beta 2\text{m}$ /peptide heterotrimeric complexes (see Parker et al., *J. Immunol.* 152:163, 1994). Alternatively, functional peptide competition assays that are known in the art may be employed. Certain immunogenic portions have one or more of the sequences recited within one or more of Tables II -
- XIV. Representative immunogenic portions include, but are not limited to, RDLNALLPAVPSLGGGG (human WT1 residues 6-22; SEQ ID NO:1), PSQASSGQARMFPNAPYLPSCLE (human and mouse WT1 residues 117-139; SEQ ID NOs: 2 and 3 respectively), GATLKGVAAGSSSVKWTE (human WT1 residues 244-262; SEQ ID NO:4), GATLKGVA (human WT1 residues 244-252; SEQ ID NO:88), CMTWNQMNL (human and mouse WT1 residues 235-243; SEQ ID NOs: 49 and 258 respectively), SCLESQPTI (mouse WT1 residues 136-144; SEQ ID NO:296), SCLESQPAI (human WT1 residues 136-144; SEQ ID NO:198), NLYQMTSQL (human and mouse WT1 residues 225-233; SEQ ID NOs: 147 and 284 respectively); ALLPAVSSL (mouse WT1 residues 10-18; SEQ ID NO:255); RMFPNAPYL (human and mouse WT1 residues 126-134; SEQ ID NOs: 185 and 293 respectively), VLDFAPPGA (human WT1 residues 37-45; SEQ ID NO:241), or VLDFAPPGAS (human WT1 residues 37-46; SEQ ID NO:411). Further immunogenic portions are provided in SEQ ID NOs:414-451. Further immunogenic portions are provided herein, and others may generally be identified using well known techniques, such as those summarized in Paul, *Fundamental Immunology*, 3rd ed., 243-247 (Raven Press, 1993) and references cited therein. Representative techniques for identifying immunogenic portions include screening polypeptides for the ability to react with antigen-specific antisera and/or T-cell lines or clones.
- An immunogenic portion of a native WT1 polypeptide is a portion that reacts with such antisera and/or T-cells at a level that is not substantially less than the

reactivity of the full length WT1 (e.g., in an ELISA and/or T-cell reactivity assay). In other words, an immunogenic portion may react within such assays at a level that is similar to or greater than the reactivity of the full length polypeptide. Such screens may generally be performed using methods well
5 known to those of ordinary skill in the art, such as those described in Harlow and Lane, *Antibodies: A Laboratory Manual*, Cold Spring Harbor Laboratory, 1988.

Alternatively, immunogenic portions may be identified using computer analysis, such as the Tsites program (see Rothbard and Taylor,
10 *EMBO J.* 7:93-100, 1988; Deavin et al., *Mol. Immunol.* 33:145-155, 1996), which searches for peptide motifs that have the potential to elicit Th responses. CTL peptides with motifs appropriate for binding to murine and human class I or class II MHC may be identified according to BIMAS (Parker et al., *J. Immunol.* 152:163, 1994) and other HLA peptide binding prediction analyses.
15 Alternatively, immunogenic portions that bind to a particular MHC molecule can be identified by using defined peptide binding motifs such as those described in Rammensee et al., *Immunogenetics* 41:178-228, 1995. To confirm peptide binding to murine and human class I or class II MHC molecules, peptide binding assays known in the art may be used. To confirm immunogenicity, a
20 peptide may be tested using an HLA A2 or other transgenic mouse model and/or an *in vitro* stimulation assay using dendritic cells, fibroblasts or peripheral blood cells.

As noted above, a composition may comprise a variant of a native WT1 protein. A polypeptide "variant," as used herein, is a polypeptide that
25 differs from a native polypeptide in one or more substitutions, deletions, additions and/or insertions, such that the immunogenicity of the polypeptide is retained (i.e., the ability of the variant to react with antigen-specific antisera and/or T-cell lines or clones is not substantially diminished relative to the native polypeptide). In other words, the ability of a variant to react with antigen-
30 specific antisera and/or T-cell lines or clones may be enhanced or unchanged, relative to the native polypeptide, or may be diminished by less than 50%, and

preferably less than 20%, relative to the native polypeptide. In one embodiment the the ability of a variant to react with antigen-specific antisera and/or T-cell lines or clones may be diminished by less than 10%, 5%, 4%, 3%, 2%, 1%, or 0.5 %, relative to the native polypeptide. Such variants may

5 generally be identified by modifying one of the above polypeptide sequences and evaluating the reactivity of the modified polypeptide with antisera and/or T-cells as described herein. In one embodiment of the present invention, a variant may be identified by evaluating its ability to bind to a human or a murine HLA molecule. In one preferred embodiment, a variant polypeptide has a

10 modification such that the ability of the variant polypeptide to bind to a class I or class II MHC molecule, for example HLA-A2, HLA-A24, HLA-A1, HLA-A3, HLA-A68, HLA-A11, HLA-A31, HLA-A33, HLA-B14, HLA-B40, HLA-B60, HLA-B62, HLA-B7, HLA-B8, HLA-B27, HLA-B3501, HLA-B37, HLA-B38, HLA-B39, HLA-B44, HLA-B51, HLA-B52, HLA-B58, HLA-CW03, HLA-CW04, HLA-CW06, or

15 HLA-CW07, is increased relative to that of a wild type (unmodified) WT1 polypeptide. In a further embodiment, the N-terminal portion of WT1 from amino acids 1-281 is modified such that the ability of any number of polypeptides therein that can bind to HLA-A2, HLA-A24, HLA-A1, HLA-A3, HLA-A68, HLA-A11, HLA-A31, HLA-A33, HLA-B14, HLA-B40, HLA-B60, HLA-

20 B62, HLA-B7, HLA-B8, HLA-B27, HLA-B3501, HLA-B37, HLA-B38, HLA-B39, HLA-B44, HLA-B51, HLA-B52, HLA-B58, HLA-CW03, HLA-CW04, HLA-CW06, or HLA-CW07 is increased relative to that of the wild type(unmodified) WT1 polypeptide sequence. In a further embodiment, a polypeptide comprising at least one immunogenic portion (epitope) is modified such that its ability to bind

25 to an MHC molecule, such as HLA-A2, HLA-A24, HLA-A1, HLA-A3, HLA-A68, HLA-A11, HLA-A31, HLA-A33, HLA-B14, HLA-B40, HLA-B60, HLA-B62, HLA-B7, HLA-B8, HLA-B27, HLA-B3501, HLA-B37, HLA-B38, HLA-B39, HLA-B44, HLA-B51, HLA-B52, HLA-B58, HLA-CW03, HLA-CW04, HLA-CW06, or HLA-CW07 is increased. Example 30 describes illustrative variants that can be

30 generated. The skilled artisan would readily recognize that these are illustrative variants and that other variants can be generated in a similar manner for

peptides that bind to HLA molecules other than HLA-A2. In a further embodiment, the ability of the variant polypeptide to bind to a HLA molecule is increased by at least 2 fold, preferably at least 3 fold, 4 fold, or 5 fold relative to that of a native WT1 polypeptide. It has been found, within the context of the present invention, that a relatively small number of substitutions (e.g., 1 to 3) within an immunogenic portion of a WT1 polypeptide may serve to enhance the ability of the polypeptide to elicit an immune response. Suitable substitutions may generally be identified by using computer programs, as described above, and the effect confirmed based on the reactivity of the modified polypeptide with antisera and/or T-cells as described herein. Accordingly, within certain preferred embodiments, a WT1 polypeptide comprises a variant in which 1 to 3 amino acid residues within an immunogenic portion are substituted such that the ability to react with antigen-specific antisera and/or T-cell lines or clones is statistically greater than that for the unmodified polypeptide. Such substitutions are preferably located within an MHC binding site of the polypeptide, which may be identified as described above. Preferred substitutions allow increased binding to MHC class I or class II molecules.

Certain variants contain conservative substitutions. A "conservative substitution" is one in which an amino acid is substituted for another amino acid that has similar properties, such that one skilled in the art of peptide chemistry would expect the secondary structure and hydrophobic nature of the polypeptide to be substantially unchanged. Amino acid substitutions may generally be made on the basis of similarity in polarity, charge, solubility, hydrophobicity, hydrophilicity and/or the amphipathic nature of the residues. For example, negatively charged amino acids include aspartic acid and glutamic acid; positively charged amino acids include lysine and arginine; and amino acids with uncharged polar head groups having similar hydrophilicity values include leucine, isoleucine and valine; glycine and alanine; asparagine and glutamine; and serine, threonine, phenylalanine and tyrosine. Other groups of amino acids that may represent conservative changes include: (1) ala, pro, gly, glu, asp, gln, asn, ser, thr; (2) cys, ser, tyr, thr; (3) val, ile, leu, met, ala,

phe; (4) lys, arg, his; and (5) phe, tyr, trp, his. A variant may also, or alternatively, contain nonconservative changes. Variants may also (or alternatively) be modified by, for example, the deletion or addition of amino acids that have minimal influence on the immunogenicity, secondary structure and hydrophobic nature of the polypeptide.

In a preferred embodiment, a variant polypeptide of the WT1 N-terminus (amino acids 1-249) is constructed, wherein the variant polypeptide is capable of binding to an antibody that recognizes full-length WT1 and/or WT1 N-terminus polypeptide. A non-limiting example of an antibody is anti WT1 antibody WT180 (Santa Cruz Biotechnology, Inc., Santa Cruz, CA).

As noted above, WT1 polypeptides may be conjugated to a signal (or leader) sequence at the N-terminal end of the protein which co-translationally or post-translationally directs transfer of the protein. A polypeptide may also, or alternatively, be conjugated to a linker or other sequence for ease of synthesis, purification or identification of the polypeptide (e.g., poly-His), or to enhance binding of the polypeptide to a solid support. For example, a polypeptide may be conjugated to an immunoglobulin Fc region.

WT1 polypeptides may be prepared using any of a variety of well known techniques. Recombinant polypeptides encoded by a WT1 polynucleotide as described herein may be readily prepared from the polynucleotide. In general, any of a variety of expression vectors known to those of ordinary skill in the art may be employed to express recombinant WT1 polypeptides. Expression may be achieved in any appropriate host cell that has been transformed or transfected with an expression vector containing a DNA molecule that encodes a recombinant polypeptide. Suitable host cells include prokaryotes, yeast and higher eukaryotic cells. Preferably, the host cells employed are *E. coli*, yeast or a mammalian cell line such as COS or CHO. Supernatants from suitable host/vector systems which secrete recombinant protein or polypeptide into culture media may be first concentrated using a commercially available filter. The concentrate may then be applied to a suitable purification matrix such as an affinity matrix or an ion exchange resin.

Finally, one or more reverse phase HPLC steps can be employed to further purify a recombinant polypeptide. Such techniques may be used to prepare native polypeptides or variants thereof. For example, polynucleotides that encode a variant of a native polypeptide may generally be prepared using
5 standard mutagenesis techniques, such as oligonucleotide-directed site-specific mutagenesis, and sections of the DNA sequence may be removed to permit preparation of truncated polypeptides.

Certain portions and other variants may also be generated by synthetic means, using techniques well known to those of ordinary skill in the
10 art. For example, polypeptides having fewer than about 500 amino acids, preferably fewer than about 100 amino acids, and more preferably fewer than about 50 amino acids, may be synthesized. Polypeptides may be synthesized using any of the commercially available solid-phase techniques, such as the Merrifield solid-phase synthesis method, where amino acids are sequentially
15 added to a growing amino acid chain. See Merrifield, *J. Am. Chem. Soc.* 85:2149-2146, 1963. Equipment for automated synthesis of polypeptides is commercially available from suppliers such as Applied BioSystems, Inc. (Foster City, CA), and may be operated according to the manufacturer's instructions.

In general, polypeptides and polynucleotides as described herein
20 are isolated. An "isolated" polypeptide or polynucleotide is one that is removed from its original environment. For example, a naturally-occurring protein is isolated if it is separated from some or all of the coexisting materials in the natural system. Preferably, such polypeptides are at least about 90% pure, more preferably at least about 95% pure and most preferably at least about
25 99% pure. A polynucleotide is considered to be isolated if, for example, it is cloned into a vector that is not a part of the natural environment.

Within further aspects, the present invention provides mimetics of WT1 polypeptides. Such mimetics may comprise amino acids linked to one or more amino acid mimetics (*i.e.*, one or more amino acids within the WT1
30 protein may be replaced by an amino acid mimetic) or may be entirely nonpeptide mimetics. An amino acid mimetic is a compound that is

conformationally similar to an amino acid such that it can be substituted for an amino acid within a WT1 polypeptide without substantially diminishing the ability to react with antigen-specific antisera and/or T cell lines or clones. A nonpeptide mimetic is a compound that does not contain amino acids, and that

5 has an overall conformation that is similar to a WT1 polypeptide such that the ability of the mimetic to react with WT1-specific antisera and/or T cell lines or clones is not substantially diminished relative to the ability of a WT1 polypeptide. Such mimetics may be designed based on standard techniques (e.g., nuclear magnetic resonance and computational techniques) that evaluate

10 the three dimensional structure of a peptide sequence. Mimetics may be designed where one or more of the side chain functionalities of the WT1 polypeptide are replaced by groups that do not necessarily have the same size or volume, but have similar chemical and/or physical properties which produce similar biological responses. It should be understood that, within embodiments

15 described herein, a mimetic may be substituted for a WT1 polypeptide.

Within other illustrative embodiments, a polypeptide may be a fusion polypeptide that comprises multiple polypeptides as described herein, or that comprises at least one polypeptide as described herein and an unrelated sequence, such as a known tumor protein. A fusion partner may, for example,

20 assist in providing T helper epitopes (an immunological fusion partner), preferably T helper epitopes recognized by humans, or may assist in expressing the protein (an expression enhancer) at higher yields than the native recombinant protein. Certain preferred fusion partners are both immunological and expression enhancing fusion partners. Other fusion

25 partners may be selected so as to increase the solubility of the polypeptide or to enable the polypeptide to be targeted to desired intracellular compartments. Still further fusion partners include affinity tags, which facilitate purification of the polypeptide.

Fusion polypeptides may generally be prepared using standard

30 techniques, including chemical conjugation. Preferably, a fusion polypeptide is expressed as a recombinant polypeptide, allowing the production of increased

levels, relative to a non-fused polypeptide, in an expression system. Briefly, DNA sequences encoding the polypeptide components may be assembled separately, and ligated into an appropriate expression vector. The 3' end of the DNA sequence encoding one polypeptide component is ligated, with or without
5 a peptide linker, to the 5' end of a DNA sequence encoding the second polypeptide component so that the reading frames of the sequences are in phase. This permits translation into a single fusion polypeptide that retains the biological activity of both component polypeptides.

A peptide linker sequence may be employed to separate the first
10 and second polypeptide components by a distance sufficient to ensure that each polypeptide folds into its secondary and tertiary structures. Such a peptide linker sequence is incorporated into the fusion polypeptide using standard techniques well known in the art. Suitable peptide linker sequences may be chosen based on the following factors: (1) their ability to adopt a
15 flexible extended conformation; (2) their inability to adopt a secondary structure that could interact with functional epitopes on the first and second polypeptides; and (3) the lack of hydrophobic or charged residues that might react with the polypeptide functional epitopes. Preferred peptide linker sequences contain Gly, Asn and Ser residues. Other near neutral amino acids, such as Thr and
20 Ala may also be used in the linker sequence. Amino acid sequences which may be usefully employed as linkers include those disclosed in Maratea et al., *Gene* 40:39-46, 1985; Murphy et al., *Proc. Natl. Acad. Sci. USA* 83:8258-8262, 1986; U.S. Patent No. 4,935,233 and U.S. Patent No. 4,751,180. The linker sequence may generally be from 1 to about 50 amino acids in length. Linker
25 sequences are not required when the first and second polypeptides have non-essential N-terminal amino acid regions that can be used to separate the functional domains and prevent steric interference.

The ligated DNA sequences are operably linked to suitable transcriptional or translational regulatory elements. The regulatory elements
30 responsible for expression of DNA are located only 5' to the DNA sequence encoding the first polypeptides. Similarly, stop codons required to end

translation and transcription termination signals are only present 3' to the DNA sequence encoding the second polypeptide.

The fusion polypeptide can comprise a polypeptide as described herein together with an unrelated immunogenic protein, such as an
5 immunogenic protein capable of eliciting a recall response. Examples of such proteins include tetanus, tuberculosis and hepatitis proteins (see, for example, Stoute et al. *New Engl. J. Med.*, 336:86-91, 1997).

In one preferred embodiment, the immunological fusion partner is derived from a *Mycobacterium* sp., such as a *Mycobacterium tuberculosis*-
10 derived Ra12 fragment. Ra12 compositions and methods for their use in enhancing the expression and/or immunogenicity of heterologous polynucleotide/polypeptide sequences is described in U.S. Patent Application 60/158,585, the disclosure of which is incorporated herein by reference in its entirety. Briefly, Ra12 refers to a polynucleotide region that is a subsequence
15 of a *Mycobacterium tuberculosis* MTB32A nucleic acid. MTB32A is a serine protease of 32 KD molecular weight encoded by a gene in virulent and avirulent strains of *M. tuberculosis*. The nucleotide sequence and amino acid sequence of MTB32A have been described (for example, U.S. Patent Application 60/158,585; see also, Skeiky et al., *Infection and Immun.* (1999) 67:3998-4007,
20 incorporated herein by reference). C-terminal fragments of the MTB32A coding sequence express at high levels and remain as soluble polypeptides throughout the purification process. Moreover, Ra12 may enhance the immunogenicity of heterologous immunogenic polypeptides with which it is fused. One preferred Ra12 fusion polypeptide comprises a 14 KD C-terminal
25 fragment corresponding to amino acid residues 192 to 323 of MTB32A. Other preferred Ra12 polynucleotides generally comprise at least about 15 consecutive nucleotides, at least about 30 nucleotides, at least about 60 nucleotides, at least about 100 nucleotides, at least about 200 nucleotides, or at least about 300 nucleotides that encode a portion of a Ra12 polypeptide.
30 Ra12 polynucleotides may comprise a native sequence (i.e., an endogenous sequence that encodes a Ra12 polypeptide or a portion thereof) or may

comprise a variant of such a sequence. Ra12 polynucleotide variants may contain one or more substitutions, additions, deletions and/or insertions such that the biological activity of the encoded fusion polypeptide is not substantially diminished, relative to a fusion polypeptide comprising a native Ra12

- 5 polypeptide. Variants preferably exhibit at least about 70% identity, more preferably at least about 80% identity and most preferably at least about 90% identity to a polynucleotide sequence that encodes a native Ra12 polypeptide or a portion thereof.

- Within other preferred embodiments, an immunological fusion
- 10 partner is derived from protein D, a surface protein of the gram-negative bacterium *Haemophilus influenza B* (WO 91/18926). Preferably, a protein D derivative comprises approximately the first third of the protein (e.g., the first N-terminal 100-110 amino acids), and a protein D derivative may be lipidated. Within certain preferred embodiments, the first 109 residues of a Lipoprotein D
- 15 fusion partner is included on the N-terminus to provide the polypeptide with additional exogenous T-cell epitopes and to increase the expression level in *E. coli* (thus functioning as an expression enhancer). The lipid tail ensures optimal presentation of the antigen to antigen presenting cells. Other fusion partners include the non-structural protein from influenzae virus, NS1
- 20 (hemagglutinin). Typically, the N-terminal 81 amino acids are used, although different fragments that include T-helper epitopes may be used.

- In another embodiment, the immunological fusion partner is the protein known as LYTA, or a portion thereof (preferably a C-terminal portion). LYTA is derived from *Streptococcus pneumoniae*, which synthesizes an N-acetyl-L-alanine amidase known as amidase LYTA (encoded by the *LytA* gene;
- 25 *Gene* 43:265-292, 1986). LYTA is an autolysin that specifically degrades certain bonds in the peptidoglycan backbone. The C-terminal domain of the LYTA protein is responsible for the affinity to the choline or to some choline analogues such as DEAE. This property has been exploited for the
- 30 development of *E. coli* C-LYTA expressing plasmids useful for expression of fusion proteins. Purification of hybrid proteins containing the C-LYTA fragment

at the amino terminus has been described (see *Biotechnology* 10:795-798, 1992). Within a preferred embodiment, a repeat portion of LYTA may be incorporated into a fusion polypeptide. A repeat portion is found in the C-terminal region starting at residue 178. A particularly preferred repeat portion

5 incorporates residues 188-305.

Within another illustrative embodiment the fusion partner comprises a twin arginine translocation (TAT) signal peptide from the TorA signal peptide in *E. coli* on the N-terminus; see J. Mol. Microbiol. (2000) 2(2): 179-189; Journal of Bacteriology, Jan 2001 p604-610 Vol 183, No 2; Journal

10 of Biochemistry Vol 276, March 16 2001 pp 8159-8164), hereby incorporated herein in its entirety.

Yet another illustrative embodiment involves fusion polypeptides, and the polynucleotides encoding them, wherein the fusion partner comprises a targeting signal capable of directing a polypeptide to the endosomal/lysosomal

15 compartment, as described in U.S. Patent No. 5,633,234. An immunogenic polypeptide of the invention, when fused with this targeting signal, will associate more efficiently with MHC class II molecules and thereby provide enhanced in vivo stimulation of CD4⁺ T-cells specific for the polypeptide.

The invention provides truncated forms of WT1 polypeptides that

20 can be recombinantly expressed in *E. coli* without the addition of a fusion partner. Examples of these truncated forms are shown in SEQ ID NOs:342-346, and are encoded by polynucleotides shown in SEQ ID NOs:337-341. In variations of these truncations, the first 76 amino acids of WT1 can be fused to the C-terminus of the protein, creating a recombinant protein that is easier to

25 express in *E. coli*. Other hosts in addition to *E. coli* can also be used, such as, for example, *B. megaterium*. The protein can further be prepared without a histidine tag.

In other embodiments, different subunits can be made and fused together in an order which differs from that of native WT1. In addition, fusions

30 can be made with, for example, Ra12. Exemplary fusion proteins are shown in

SEQ ID NOs: 332-336 and can be encoded by polynucleotides shown in SEQ ID NOs: 327-331.

WT1 Polynucleotides

Any polynucleotide that encodes a WT1 polypeptide as described
5 herein is a WT1 polynucleotide encompassed by the present invention. Such polynucleotides may be single-stranded (coding or antisense) or double-stranded, and may be DNA (genomic, cDNA or synthetic) or RNA molecules. Additional coding or non-coding sequences may, but need not, be present within a polynucleotide of the present invention, and a polynucleotide may, but
10 need not, be linked to other molecules and/or support materials.

WT1 polynucleotides may encode a native WT1 protein, or may encode a variant of WT1 as described herein. Polynucleotide variants may contain one or more substitutions, additions, deletions and/or insertions such that the immunogenicity of the encoded polypeptide is not diminished, relative
15 to a native WT1 protein. The effect on the immunogenicity of the encoded polypeptide may generally be assessed as described herein. Preferred variants contain nucleotide substitutions, deletions, insertions and/or additions at no more than 20%, preferably at no more than 10%, of the nucleotide positions that encode an immunogenic portion of a native WT1 sequence.
20 Certain variants are substantially homologous to a native gene, or a portion thereof. Such polynucleotide variants are capable of hybridizing under moderately stringent conditions to a naturally occurring DNA sequence encoding a WT1 polypeptide (or a complementary sequence). Suitable moderately stringent conditions include prewashing in a solution of 5 X SSC,
25 0.5% SDS, 1.0 mM EDTA (pH 8.0); hybridizing at 50°C-65°C, 5 X SSC, overnight; followed by washing twice at 65°C for 20 minutes with each of 2X, 0.5X and 0.2X SSC containing 0.1% SDS). Such hybridizing DNA sequences are also within the scope of this invention.

It will be appreciated by those of ordinary skill in the art that, as a
30 result of the degeneracy of the genetic code, there are many nucleotide

sequences that encode a WT1 polypeptide. Some of these polynucleotides bear minimal homology to the nucleotide sequence of any native gene. Nonetheless, polynucleotides that vary due to differences in codon usage are specifically contemplated by the present invention.

- 5 Therefore, according to another aspect of the present invention, polynucleotide compositions are provided that comprise some or all of a polynucleotide sequence set forth herein, complements of a polynucleotide sequence set forth herein, and degenerate variants of a polynucleotide sequence set forth herein. In certain preferred embodiments, the
- 10 polynucleotide sequences set forth herein encode immunogenic polypeptides, as described above.

- Once an immunogenic portion of WT1 is identified, as described above, a WT1 polynucleotide may be prepared using any of a variety of techniques. For example, a WT1 polynucleotide may be amplified from cDNA
- 15 prepared from cells that express WT1. Such polynucleotides may be amplified via polymerase chain reaction (PCR). For this approach, sequence-specific primers may be designed based on the sequence of the immunogenic portion and may be purchased or synthesized. For example, suitable primers for PCR amplification of a human WT1 gene include: first step - P118: 1434-1414: 5'
- 20 GAG AGT CAG ACT TGA AAG CAGT 3' (SEQ ID NO:5) and P135: 5' CTG AGC CTC AGC AAA TGG GC 3' (SEQ ID NO:6); second step - P136: 5' GAG CAT GCA TGG GCT CCG ACG TGC GGG 3' (SEQ ID NO:7) and P137: 5' GGG GTA CCC ACT GAA CGG TCC CCG A 3' (SEQ ID NO:8). Primers for PCR amplification of a mouse WT1 gene include: first step - P138: 5' TCC
- 25 GAG CCG CAC CTC ATG 3' (SEQ ID NO:9) and P139: 5' GCC TGG GAT GCT GGA CTG 3' (SEQ ID NO:10), second step - P140: 5' GAG CAT GCG ATG GGT TCC GAC GTG CGG 3' (SEQ ID NO:11) and P141: 5' GGG GTA CCT CAA AGC GCC ACG TGG AGT TT 3' (SEQ ID NO:12).

- An amplified portion may then be used to isolate a full length
- 30 gene from a human genomic DNA library or from a suitable cDNA library, using well known techniques. Alternatively, a full length gene can be constructed

from multiple PCR fragments. WT1 polynucleotides may also be prepared by synthesizing oligonucleotide components, and ligating components together to generate the complete polynucleotide.

WT1 polynucleotides may also be synthesized by any method known in the art, including chemical synthesis (e.g., solid phase phosphoramidite chemical synthesis). Modifications in a polynucleotide sequence may also be introduced using standard mutagenesis techniques, such as oligonucleotide-directed site-specific mutagenesis (see Adelman et al., *DNA* 2:183, 1983). Alternatively, RNA molecules may be generated by *in vitro* or *in vivo* transcription of DNA sequences encoding a WT1 polypeptide, provided that the DNA is incorporated into a vector with a suitable RNA polymerase promoter (such as T7 or SP6). Certain portions may be used to prepare an encoded polypeptide, as described herein. In addition, or alternatively, a portion may be administered to a patient such that the encoded polypeptide is generated *in vivo* (e.g., by transfecting antigen-presenting cells such as dendritic cells with a cDNA construct encoding a WT1 polypeptide, and administering the transfected cells to the patient).

Polynucleotides that encode a WT1 polypeptide may generally be used for production of the polypeptide, *in vitro* or *in vivo*. WT1 polynucleotides that are complementary to a coding sequence (i.e., antisense polynucleotides) may also be used as a probe or to inhibit WT1 expression. cDNA constructs that can be transcribed into antisense RNA may also be introduced into cells of tissues to facilitate the production of antisense RNA.

Any polynucleotide may be further modified to increase stability *in vivo*. Possible modifications include, but are not limited to, the addition of flanking sequences at the 5' and/or 3' ends; the use of phosphorothioate or 2' O-methyl rather than phosphodiesterase linkages in the backbone; and/or the inclusion of nontraditional bases such as inosine, queosine and wybutosine, as well as acetyl-, methyl-, thio- and other modified forms of adenine, cytidine, guanine, thymine and uridine.

Nucleotide sequences as described herein may be joined to a variety of other nucleotide sequences using established recombinant DNA techniques. For example, a polynucleotide may be cloned into any of a variety of cloning vectors, including plasmids, phagemids, lambda phage derivatives and cosmids. Vectors of particular interest include expression vectors, replication vectors, probe generation vectors and sequencing vectors. In general, a vector will contain an origin of replication functional in at least one organism, convenient restriction endonuclease sites and one or more selectable markers. Other elements will depend upon the desired use, and will be apparent to those of ordinary skill in the art. In particular, one embodiment of the invention comprises expression vectors which incorporate the nucleic acid molecules of the invention, in operable linkage (i.e., "operably linked") to an expression control sequence (promoter). Construction of such vectors, such as viral (e.g., adenovirus or Vaccinia virus) or attenuated viral vectors is well within the skill of the art, as is the transformation or transfection of cells, to produce eukaryotic cell lines, or prokaryotic cell strains which encode the molecule of interest. Exemplary of the host cells which can be employed in this fashion are COS cells, CHO cells, yeast cells, insect cells (e.g., *Spodoptera frugiperda* or Sf-9 cells), NIH 3T3 cells, and so forth. Prokaryotic cells, such as *E. coli* and other bacteria may also be used.

Within certain embodiments, polynucleotides may be formulated so as to permit entry into a cell of a mammal, and expression therein. Such formulations are particularly useful for therapeutic purposes, as described below. Those of ordinary skill in the art will appreciate that there are many ways to achieve expression of a polynucleotide in a target cell, and any suitable method may be employed. For example, a polynucleotide may be incorporated into a viral vector such as, but not limited to, adenovirus, adeno-associated virus, retrovirus, or vaccinia or other pox virus (e.g., avian pox virus). Techniques for incorporating DNA into such vectors are well known to those of ordinary skill in the art. A retroviral vector may additionally transfer or incorporate a gene for a selectable marker (to aid in the identification or

selection of transduced cells) and/or a targeting moiety, such as a gene that encodes a ligand for a receptor on a specific target cell, to render the vector target specific. Targeting may also be accomplished using an antibody, by methods known to those of ordinary skill in the art. cDNA constructs within
5 such a vector may be used, for example, to transfect human or animal cell lines for use in establishing WT1 positive tumor models which may be used to perform tumor protection and adoptive immunotherapy experiments to demonstrate tumor or leukemia-growth inhibition or lysis of such cells.

Other therapeutic formulations for polynucleotides include
10 colloidal dispersion systems, such as macromolecule complexes, nanocapsules, microspheres, beads, and lipid-based systems including oil-in-water emulsions, micelles, mixed micelles, and liposomes. A preferred colloidal system for use as a delivery vehicle *in vitro* and *in vivo* is a liposome (i.e., an artificial membrane vesicle). The preparation and use of such systems
15 is well known in the art.

Antibody Compositions, Fragments Thereof and Other Binding Agents

According to another aspect, the present invention further provides binding agents, such as antibodies and antigen-binding fragments thereof, that exhibit immunological binding to a WT1 polypeptide disclosed
20 herein, or to a portion, variant or derivative thereof. An antibody, or antigen-binding fragment thereof, is said to "specifically bind," "immunologically bind," and/or is "immunologically reactive" to a WT1 polypeptide of the invention if it reacts at a detectable level (within, for example, an ELISA assay) with the polypeptide, and does not react detectably with unrelated polypeptides under
25 similar conditions.

Immunological binding, as used in this context, generally refers to the non-covalent interactions of the type which occur between an immunoglobulin molecule and an antigen for which the immunoglobulin is specific. The strength, or affinity of immunological binding interactions can be
30 expressed in terms of the dissociation constant (K_d) of the interaction, wherein

a smaller K_d represents a greater affinity. Immunological binding properties of selected polypeptides can be quantified using methods well known in the art. One such method entails measuring the rates of antigen-binding site/antigen complex formation and dissociation, wherein those rates depend on the concentrations of the complex partners, the affinity of the interaction, and on geometric parameters that equally influence the rate in both directions. Thus, both the "on rate constant" (K_{on}) and the "off rate constant" (K_{off}) can be determined by calculation of the concentrations and the actual rates of association and dissociation. The ratio of K_{off}/K_{on} enables cancellation of all parameters not related to affinity, and is thus equal to the dissociation constant K_d . See, generally, Davies et al. (1990) Annual Rev. Biochem. 59:439-473.

An "antigen-binding site," or "binding portion" of an antibody refers to the part of the immunoglobulin molecule that participates in antigen binding. The antigen binding site is formed by amino acid residues of the N-terminal variable ("V") regions of the heavy ("H") and light ("L") chains. Three highly divergent stretches within the V regions of the heavy and light chains are referred to as "hypervariable regions" which are interposed between more conserved flanking stretches known as "framework regions," or "FRs". Thus the term "FR" refers to amino acid sequences which are naturally found between and adjacent to hypervariable regions in immunoglobulins. In an antibody molecule, the three hypervariable regions of a light chain and the three hypervariable regions of a heavy chain are disposed relative to each other in three dimensional space to form an antigen-binding surface. The antigen-binding surface is complementary to the three-dimensional surface of a bound antigen, and the three hypervariable regions of each of the heavy and light chains are referred to as "complementarity-determining regions," or "CDRs."

Binding agents may be further capable of differentiating between patients with and without a WT1-associated cancer, using the representative assays provided herein. For example, antibodies or other binding agents that bind to a tumor protein will preferably generate a signal indicating the presence of a cancer in at least about 20% of patients with the disease, more preferably

at least about 30% of patients. Alternatively, or in addition, the antibody will generate a negative signal indicating the absence of the disease in at least about 90% of individuals without the cancer. To determine whether a binding agent satisfies this requirement, biological samples (e.g., blood, sera, sputum, urine and/or tumor biopsies) from patients with and without a cancer (as determined using standard clinical tests) may be assayed as described herein for the presence of polypeptides that bind to the binding agent. Preferably, a statistically significant number of samples with and without the disease will be assayed. Each binding agent should satisfy the above criteria; however, those of ordinary skill in the art will recognize that binding agents may be used in combination to improve sensitivity.

Any agent that satisfies the above requirements may be a binding agent. For example, a binding agent may be a ribosome, with or without a peptide component, an RNA molecule or a polypeptide. In a preferred embodiment, a binding agent is an antibody or an antigen-binding fragment thereof. Antibodies may be prepared by any of a variety of techniques known to those of ordinary skill in the art. See, e.g., Harlow and Lane, *Antibodies: A Laboratory Manual*, Cold Spring Harbor Laboratory, 1988. In general, antibodies can be produced by cell culture techniques, including the generation of monoclonal antibodies as described herein, or via transfection of antibody genes into suitable bacterial or mammalian cell hosts, in order to allow for the production of recombinant antibodies. In one technique, an immunogen comprising the polypeptide is initially injected into any of a wide variety of mammals (e.g., mice, rats, rabbits, sheep or goats). In this step, polypeptides of this invention may serve as the immunogen without modification. Alternatively, particularly for relatively short polypeptides, a superior immune response may be elicited if the polypeptide is joined to a carrier protein, such as bovine serum albumin or keyhole limpet hemocyanin. The immunogen is injected into the animal host, preferably according to a predetermined schedule incorporating one or more booster immunizations, and the animals are bled periodically. Polyclonal antibodies specific for the

polypeptide may then be purified from such antisera by, for example, affinity chromatography using the polypeptide coupled to a suitable solid support.

- Monoclonal antibodies specific for an antigenic polypeptide of interest may be prepared, for example, using the technique of Kohler and Milstein, *Eur. J. Immunol.* 6:511-519, 1976, and improvements thereto. Briefly, these methods involve the preparation of immortal cell lines capable of producing antibodies having the desired specificity (*i.e.*, reactivity with the polypeptide of interest). Such cell lines may be produced, for example, from spleen cells obtained from an animal immunized as described above. The spleen cells are then immortalized by, for example, fusion with a myeloma cell fusion partner, preferably one that is syngeneic with the immunized animal. A variety of fusion techniques may be employed. For example, the spleen cells and myeloma cells may be combined with a nonionic detergent for a few minutes and then plated at low density on a selective medium that supports the growth of hybrid cells, but not myeloma cells. A preferred selection technique uses HAT (hypoxanthine, aminopterin, thymidine) selection. After a sufficient time, usually about 1 to 2 weeks, colonies of hybrids are observed. Single colonies are selected and their culture supernatants tested for binding activity against the polypeptide. Hybridomas having high reactivity and specificity are preferred.

- Monoclonal antibodies may be isolated from the supernatants of growing hybridoma colonies. In addition, various techniques may be employed to enhance the yield, such as injection of the hybridoma cell line into the peritoneal cavity of a suitable vertebrate host, such as a mouse. Monoclonal antibodies may then be harvested from the ascites fluid or the blood. Contaminants may be removed from the antibodies by conventional techniques, such as chromatography, gel filtration, precipitation, and extraction. The polypeptides of this invention may be used in the purification process in, for example, an affinity chromatography step.

- A number of therapeutically useful molecules are known in the art which comprise antigen-binding sites that are capable of exhibiting

- immunological binding properties of an antibody molecule. The proteolytic enzyme papain preferentially cleaves IgG molecules to yield several fragments, two of which (the "F(ab)" fragments) each comprise a covalent heterodimer that includes an intact antigen-binding site. The enzyme pepsin is able to cleave
- 5 IgG molecules to provide several fragments, including the "F(ab')₂" fragment which comprises both antigen-binding sites. An "Fv" fragment can be produced by preferential proteolytic cleavage of an IgM, and on rare occasions IgG or IgA immunoglobulin molecule. Fv fragments are, however, more commonly derived using recombinant techniques known in the art. The Fv fragment includes a
- 10 non-covalent V_H::V_L heterodimer including an antigen-binding site which retains much of the antigen recognition and binding capabilities of the native antibody molecule. Inbar et al. (1972) Proc. Nat. Acad. Sci. USA 69:2659-2662; Hochman et al. (1976) Biochem 15:2706-2710; and Ehrlich et al. (1980) Biochem 19:4091-4096.
- 15 A single chain Fv ("sFv") polypeptide is a covalently linked V_H::V_L heterodimer which is expressed from a gene fusion including V_H- and V_L-encoding genes linked by a peptide-encoding linker. Huston et al. (1988) Proc. Nat. Acad. Sci. USA 85(16):5879-5883. A number of methods have been described to discern chemical structures for converting the naturally
- 20 aggregated--but chemically separated--light and heavy polypeptide chains from an antibody V region into an sFv molecule which will fold into a three dimensional structure substantially similar to the structure of an antigen-binding site. See, e.g., U.S. Pat. Nos. 5,091,513 and 5,132,405, to Huston et al.; and U.S. Pat. No. 4,946,778, to Ladner et al.
- 25 Each of the above-described molecules includes a heavy chain and a light chain CDR set, respectively interposed between a heavy chain and a light chain FR set which provide support to the CDRs and define the spatial relationship of the CDRs relative to each other. As used herein, the term "CDR set" refers to the three hypervariable regions of a heavy or light chain V region.
- 30 Proceeding from the N-terminus of a heavy or light chain, these regions are denoted as "CDR1," "CDR2," and "CDR3" respectively. An antigen-binding site,

therefore, includes six CDRs, comprising the CDR set from each of a heavy and a light chain V region. A polypeptide comprising a single CDR, (e.g., a CDR1, CDR2 or CDR3) is referred to herein as a "molecular recognition unit."

Crystallographic analysis of a number of antigen-antibody complexes has demonstrated that the amino acid residues of CDRs form extensive contact with bound antigen, wherein the most extensive antigen contact is with the heavy chain CDR3. Thus, the molecular recognition units are primarily responsible for the specificity of an antigen-binding site.

As used herein, the term "FR set" refers to the four flanking amino acid sequences which frame the CDRs of a CDR set of a heavy or light chain V region. Some FR residues may contact bound antigen; however, FRs are primarily responsible for folding the V region into the antigen-binding site, particularly the FR residues directly adjacent to the CDRs. Within FRs, certain amino acid residues and certain structural features are very highly conserved. In this regard, all V region sequences contain an internal disulfide loop of around 90 amino acid residues. When the V regions fold into a binding-site, the CDRs are displayed as projecting loop motifs which form an antigen-binding surface. It is generally recognized that there are conserved structural regions of FRs which influence the folded shape of the CDR loops into certain "canonical" structures--regardless of the precise CDR amino acid sequence. Further, certain FR residues are known to participate in non-covalent interdomain contacts which stabilize the interaction of the antibody heavy and light chains.

A number of "humanized" antibody molecules comprising an antigen-binding site derived from a non-human immunoglobulin have been described, including chimeric antibodies having rodent V regions and their associated CDRs fused to human constant domains (Winter et al. (1991) Nature 349:293-299; Lobuglio et al. (1989) Proc. Nat. Acad. Sci. USA 86:4220-4224; Shaw et al. (1987) J Immunol. 138:4534-4538; and Brown et al. (1987) Cancer Res. 47:3577-3583), rodent CDRs grafted into a human supporting FR prior to fusion with an appropriate human antibody constant domain (Riechmann et al. (1988) Nature 332:323-327; Verhoeyen et al. (1988) Science

239:1534-1536; and Jones et al. (1986) Nature 321:522-525), and rodent CDRs supported by recombinantly veneered rodent FRs (European Patent Publication No. 519,596, published Dec. 23, 1992). These "humanized" molecules are designed to minimize unwanted immunological response toward rodent antihuman antibody molecules which limits the duration and effectiveness of therapeutic applications of those moieties in human recipients.

As used herein, the terms "veneered FRs" and "recombinantly veneered FRs" refer to the selective replacement of FR residues from, e.g., a rodent heavy or light chain V region, with human FR residues in order to provide a xenogeneic molecule comprising an antigen-binding site which retains substantially all of the native FR polypeptide folding structure. Veneering techniques are based on the understanding that the ligand binding characteristics of an antigen-binding site are determined primarily by the structure and relative disposition of the heavy and light chain CDR sets within the antigen-binding surface. Davies et al. (1990) Ann. Rev. Biochem. 59:439-473. Thus, antigen binding specificity can be preserved in a humanized antibody only wherein the CDR structures, their interaction with each other, and their interaction with the rest of the V region domains are carefully maintained. By using veneering techniques, exterior (e.g., solvent-accessible) FR residues which are readily encountered by the immune system are selectively replaced with human residues to provide a hybrid molecule that comprises either a weakly immunogenic, or substantially non-immunogenic veneered surface.

The process of veneering makes use of the available sequence data for human antibody variable domains compiled by Kabat et al., in Sequences of Proteins of Immunological Interest, 4th ed., (U.S. Dept. of Health and Human Services, U.S. Government Printing Office, 1987), updates to the Kabat database, and other accessible U.S. and foreign databases (both nucleic acid and protein). Solvent accessibilities of V region amino acids can be deduced from the known three-dimensional structure for human and murine antibody fragments. There are two general steps in veneering a murine antigen-binding site. Initially, the FRs of the variable domains of an antibody

molecule of interest are compared with corresponding FR sequences of human variable domains obtained from the above-identified sources. The most homologous human V regions are then compared residue by residue to corresponding murine amino acids. The residues in the murine FR which differ
5 from the human counterpart are replaced by the residues present in the human moiety using recombinant techniques well known in the art. Residue switching is only carried out with moieties which are at least partially exposed (solvent accessible), and care is exercised in the replacement of amino acid residues which may have a significant effect on the tertiary structure of V region
10 domains, such as proline, glycine and charged amino acids.

In this manner, the resultant "veneered" murine antigen-binding sites are thus designed to retain the murine CDR residues, the residues substantially adjacent to the CDRs, the residues identified as buried or mostly buried (solvent inaccessible), the residues believed to participate in non-
15 covalent (e.g., electrostatic and hydrophobic) contacts between heavy and light chain domains, and the residues from conserved structural regions of the FRs which are believed to influence the "canonical" tertiary structures of the CDR loops. These design criteria are then used to prepare recombinant nucleotide sequences which combine the CDRs of both the heavy and light chain of a
20 murine antigen-binding site into human-appearing FRs that can be used to transfect mammalian cells for the expression of recombinant human antibodies which exhibit the antigen specificity of the murine antibody molecule.

In another embodiment of the invention, monoclonal antibodies of the present invention may be coupled to one or more therapeutic agents.
25 Suitable agents in this regard include radionuclides, differentiation inducers, drugs, toxins, and derivatives thereof. Preferred radionuclides include ^{90}Y , ^{123}I , ^{125}I , ^{131}I , ^{186}Re , ^{188}Re , ^{211}At , and ^{212}Bi . Preferred drugs include methotrexate, and pyrimidine and purine analogs. Preferred differentiation inducers include phorbol esters and butyric acid. Preferred toxins include ricin, abrin, diphtheria
30 toxin, cholera toxin, gelonin, *Pseudomonas* exotoxin, *Shigella* toxin, and pokeweed antiviral protein.

A therapeutic agent may be coupled (e.g., covalently bonded) to a suitable monoclonal antibody either directly or indirectly (e.g., via a linker group). A direct reaction between an agent and an antibody is possible when each possesses a substituent capable of reacting with the other. For example, 5 a nucleophilic group, such as an amino or sulfhydryl group, on one may be capable of reacting with a carbonyl-containing group, such as an anhydride or an acid halide, or with an alkyl group containing a good leaving group (e.g., a halide) on the other.

Alternatively, it may be desirable to couple a therapeutic agent 10 and an antibody via a linker group. A linker group can function as a spacer to distance an antibody from an agent in order to avoid interference with binding capabilities. A linker group can also serve to increase the chemical reactivity of a substituent on an agent or an antibody, and thus increase the coupling efficiency. An increase in chemical reactivity may also facilitate the use of 15 agents, or functional groups on agents, which otherwise would not be possible.

It will be evident to those skilled in the art that a variety of bifunctional or polyfunctional reagents, both homo- and hetero-functional (such as those described in the catalog of the Pierce Chemical Co., Rockford, IL), may be employed as the linker group. Coupling may be effected, for example, 20 through amino groups, carboxyl groups, sulfhydryl groups or oxidized carbohydrate residues. There are numerous references describing such methodology, e.g., U.S. Patent No. 4,671,958, to Rodwell et al.

Where a therapeutic agent is more potent when free from the antibody portion of the immunoconjugates of the present invention, it may be 25 desirable to use a linker group which is cleavable during or upon internalization into a cell. A number of different cleavable linker groups have been described. The mechanisms for the intracellular release of an agent from these linker groups include cleavage by reduction of a disulfide bond (e.g., U.S. Patent No. 4,489,710, to Spittler), by irradiation of a photolabile bond (e.g., U.S. Patent 30 No. 4,625,014, to Senter et al.), by hydrolysis of derivatized amino acid side chains (e.g., U.S. Patent No. 4,638,045, to Kohn et al.), by serum complement-

mediated hydrolysis (e.g., U.S. Patent No. 4,671,958, to Rodwell et al.), and acid-catalyzed hydrolysis (e.g., U.S. Patent No. 4,569,789, to Blattler et al.).

It may be desirable to couple more than one agent to an antibody.

In one embodiment, multiple molecules of an agent are coupled to one antibody molecule. In another embodiment, more than one type of agent may be coupled to one antibody. Regardless of the particular embodiment, immunoconjugates with more than one agent may be prepared in a variety of ways. For example, more than one agent may be coupled directly to an antibody molecule, or linkers that provide multiple sites for attachment can be used. Alternatively, a carrier can be used.

A carrier may bear the agents in a variety of ways, including covalent bonding either directly or via a linker group. Suitable carriers include proteins such as albumins (e.g., U.S. Patent No. 4,507,234, to Kato et al.), peptides and polysaccharides such as aminodextran (e.g., U.S. Patent No. 4,699,784, to Shih et al.). A carrier may also bear an agent by noncovalent bonding or by encapsulation, such as within a liposome vesicle (e.g., U.S. Patent Nos. 4,429,008 and 4,873,088). Carriers specific for radionuclide agents include radiohalogenated small molecules and chelating compounds. For example, U.S. Patent No. 4,735,792 discloses representative radiohalogenated small molecules and their syntheses. A radionuclide chelate may be formed from chelating compounds that include those containing nitrogen and sulfur atoms as the donor atoms for binding the metal, or metal oxide, radionuclide. For example, U.S. Patent No. 4,673,562, to Davison et al. discloses representative chelating compounds and their synthesis.

25 T Cells

Immunotherapeutic compositions may also, or alternatively, comprise T cells specific for WT1. Such cells may generally be prepared *in vitro* or *ex vivo*, using standard procedures. For example, T cells may be present within (or isolated from) bone marrow, peripheral blood or a fraction of bone marrow or peripheral blood of a mammal, such as a patient, using a

commercially available cell separation system, such as the CEPRATE™ system, available from CellPro Inc., Bothell WA (see also U.S. Patent No. 5,240,856; U.S. Patent No. 5,215,926; WO 89/06280; WO 91/16116 and WO 92/07243). Alternatively, T cells may be derived from related or unrelated
5 humans, non-human animals, cell lines or cultures.

T cells may be stimulated with WT1 polypeptide, polynucleotide encoding a WT1 polypeptide and/or an antigen presenting cell (APC) that expresses a WT1 polypeptide. Such stimulation is performed under conditions and for a time sufficient to permit the generation of T cells that are specific for
10 the WT1 polypeptide. Preferably, a WT1 polypeptide or polynucleotide is present within a delivery vehicle, such as a microsphere, to facilitate the generation of antigen-specific T cells. Briefly, T cells, which may be isolated from a patient or a related or unrelated donor by routine techniques (such as by Ficol/Hypaque density gradient centrifugation of peripheral blood lymphocytes),
15 are incubated with WT1 polypeptide. For example, T cells may be incubated *in vitro* for 2-9 days (typically 4 days) at 37°C with WT1 polypeptide (e.g., 5 to 25 µg/ml) or cells synthesizing a comparable amount of WT1 polypeptide. It may be desirable to incubate a separate aliquot of a T cell sample in the absence of WT1 polypeptide to serve as a control.

20 T cells are considered to be specific for a WT1 polypeptide if the T cells kill target cells coated with a WT1 polypeptide or expressing a gene encoding such a polypeptide. T cell specificity may be evaluated using any of a variety of standard techniques. For example, within a chromium release assay or proliferation assay, a stimulation index of more than two fold increase in lysis
25 and/or proliferation, compared to negative controls, indicates T cell specificity. Such assays may be performed, for example, as described in Chen et al., *Cancer Res.* 54:1065-1070, 1994. Alternatively, detection of the proliferation of T cells may be accomplished by a variety of known techniques. For example, T cell proliferation can be detected by measuring an increased rate of DNA
30 synthesis (e.g., by pulse-labeling cultures of T cells with tritiated thymidine and measuring the amount of tritiated thymidine incorporated into DNA). Other

ways to detect T cell proliferation include measuring increases in interleukin-2 (IL-2) production, Ca^{2+} flux, or dye uptake, such as 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl-tetrazolium. Alternatively, synthesis of lymphokines (such as interferon-gamma) can be measured or the relative number of T cells that can respond to a WT1 polypeptide may be quantified. Contact with a WT1 polypeptide (200 ng/ml - 100 $\mu\text{g}/\text{ml}$, preferably 100 ng/ml - 25 $\mu\text{g}/\text{ml}$) for 3 - 7 days should result in at least a two fold increase in proliferation of the T cells and/or contact as described above for 2-3 hours should result in activation of the T cells, as measured using standard cytokine assays in which a two fold increase in the level of cytokine release (e.g., TNF or IFN- γ) is indicative of T cell activation (see Coligan et al., Current Protocols in Immunology, vol. 1, Wiley Interscience (Greene 1998). WT1 specific T cells may be expanded using standard techniques. Within preferred embodiments, the T cells are derived from a patient or a related or unrelated donor and are administered to the patient following stimulation and expansion.

T cells that have been activated in response to a WT1 polypeptide, polynucleotide or WT1-expressing APC may be CD4^+ and/or CD8^+ . Specific activation of CD4^+ or CD8^+ T cells may be detected in a variety of ways. Methods for detecting specific T cell activation include detecting the proliferation of T cells, the production of cytokines (e.g., lymphokines), or the generation of cytolytic activity (i.e., generation of cytotoxic T cells specific for WT1). For CD4^+ T cells, a preferred method for detecting specific T cell activation is the detection of the proliferation of T cells. For CD8^+ T cells, a preferred method for detecting specific T cell activation is the detection of the generation of cytolytic activity.

For therapeutic purposes, CD4^+ or CD8^+ T cells that proliferate in response to the WT1 polypeptide, polynucleotide or APC can be expanded in number either *in vitro* or *in vivo*. Proliferation of such T cells *in vitro* may be accomplished in a variety of ways. For example, the T cells can be re-exposed to WT1 polypeptide, with or without the addition of T cell growth factors, such as interleukin-2, and/or stimulator cells that synthesize a WT1 polypeptide.

- The addition of stimulator cells is preferred where generating CD8⁺ T cell responses. T cells can be grown to large numbers *in vitro* with retention of specificity in response to intermittent restimulation with WT1 polypeptide. Briefly, for the primary *in vitro* stimulation (IVS), large numbers of lymphocytes
- 5 (e.g., greater than 4×10^7) may be placed in flasks with media containing human serum. WT1 polypeptide (e.g., peptide at 10 µg/ml) may be added directly, along with tetanus toxoid (e.g., 5 µg/ml). The flasks may then be incubated (e.g., 37°C for 7 days). For a second IVS, T cells are then harvested and placed in new flasks with $2-3 \times 10^7$ irradiated peripheral blood
- 10 mononuclear cells. WT1 polypeptide (e.g., 10 µg/ml) is added directly. The flasks are incubated at 37°C for 7 days. On day 2 and day 4 after the second IVS, 2-5 units of interleukin-2 (IL-2) may be added. For a third IVS, the T cells may be placed in wells and stimulated with the individual's own EBV transformed B cells coated with the peptide. IL-2 may be added on days 2 and
- 15 4 of each cycle. As soon as the cells are shown to be specific cytotoxic T cells, they may be expanded using a 10 day stimulation cycle with higher IL-2 (20 units) on days 2, 4 and 6.

- Alternatively, one or more T cells that proliferate in the presence of WT1 polypeptide can be expanded in number by cloning. Methods for
- 20 cloning cells are well known in the art, and include limiting dilution. Responder T cells may be purified from the peripheral blood of sensitized patients by density gradient centrifugation and sheep red cell rosetting and established in culture by stimulating with the nominal antigen in the presence of irradiated autologous filler cells. In order to generate CD4⁺ T cell lines, WT1 polypeptide
- 25 is used as the antigenic stimulus and autologous peripheral blood lymphocytes (PBL) or lymphoblastoid cell lines (LCL) immortalized by infection with Epstein Barr virus are used as antigen presenting cells. In order to generate CD8⁺ T cell lines, autologous antigen-presenting cells transfected with an expression vector which produces WT1 polypeptide may be used as stimulator cells.
- 30 Established T cell lines may be cloned 2-4 days following antigen stimulation by plating stimulated T cells at a frequency of 0.5 cells per well in 96-well flat-

bottom plates with 1×10^6 irradiated PBL or LCL cells and recombinant interleukin-2 (rIL2) (50 U/ml). Wells with established clonal growth may be identified at approximately 2-3 weeks after initial plating and restimulated with appropriate antigen in the presence of autologous antigen-presenting cells, then subsequently expanded by the addition of low doses of rIL2 (10 U/ml) 2-3 days following antigen stimulation. T cell clones may be maintained in 24-well plates by periodic restimulation with antigen and rIL2 approximately every two weeks.

Within certain embodiments, allogeneic T-cells may be primed (i.e., sensitized to WT1) *in vivo* and/or *in vitro*. Such priming may be achieved by contacting T cells with a WT1 polypeptide, a polynucleotide encoding such a polypeptide or a cell producing such a polypeptide under conditions and for a time sufficient to permit the priming of T cells. In general, T cells are considered to be primed if, for example, contact with a WT1 polypeptide results in proliferation and/or activation of the T cells, as measured by standard proliferation, chromium release and/or cytokine release assays as described herein. A stimulation index of more than two fold increase in proliferation or lysis, and more than three fold increase in the level of cytokine, compared to negative controls, indicates T-cell specificity. Cells primed *in vitro* may be employed, for example, within a bone marrow transplantation or as donor lymphocyte infusion.

T cells specific for WT1 can kill cells that express WT1 protein. Introduction of genes encoding T-cell receptor (TCR) chains for WT1 are used as a means to quantitatively and qualitatively improve responses to WT1 bearing leukemia and cancer cells. Vaccines to increase the number of T cells that can react to WT1 positive cells are one method of targeting WT1 bearing cells. T cell therapy with T cells specific for WT1 is another method. An alternative method is to introduce the TCR chains specific for WT1 into T cells or other cells with lytic potential. In a suitable embodiment, the TCR alpha and beta chains are cloned out from a WT1 specific T cell line and used for

adoptive T cell therapy, such as described in WO96/30516, incorporated herein by reference.

T Cell Receptor Compositions

- The T cell receptor (TCR) consists of 2 different, highly variable polypeptide chains, termed the T-cell receptor α and β chains, that are linked by a disulfide bond (Janeway, Travers, Walport. Immunobiology. Fourth Ed., 148-159. Elsevier Science Ltd/Garland Publishing. 1999). The α/β heterodimer complexes with the invariant CD3 chains at the cell membrane. This complex recognizes specific antigenic peptides bound to MHC molecules. The enormous diversity of TCR specificities is generated much like immunoglobulin diversity, through somatic gene rearrangement. The β chain genes contain over 50 variable (V), 2 diversity (D), over 10 joining (J) segments, and 2 constant region segments (C). The α chain genes contain over 70 V segments, and over 60 J segments but no D segments, as well as one C segment. During T cell development in the thymus, the D to J gene rearrangement of the β chain occurs, followed by the V gene segment rearrangement to the DJ. This functional VDJ β exon is transcribed and spliced to join to a C β . For the α chain, a V α gene segment rearranges to a J α gene segment to create the functional exon that is then transcribed and spliced to the C α . Diversity is further increased during the recombination process by the random addition of P and N-nucleotides between the V, D, and J segments of the β chain and between the V and J segments in the α chain (Janeway, Travers, Walport. Immunobiology. Fourth Ed., 98 and 150. Elsevier Science Ltd/Garland Publishing. 1999).
- The present invention, in another aspect, provides TCRs specific for a polypeptide disclosed herein, or for a variant or derivative thereof. In accordance with the present invention, polynucleotide and amino acid sequences are provided for the V-J or V-D-J junctional regions or parts thereof for the alpha and beta chains of the T-cell receptor which recognize tumor polypeptides described herein. In general, this aspect of the invention relates

to T-cell receptors which recognize or bind tumor polypeptides presented in the context of MHC. In a preferred embodiment the tumor antigens recognized by the T-cell receptors comprise a polypeptide of the present invention. For example, cDNA encoding a TCR specific for a WT1 peptide can be isolated
5 from T cells specific for a tumor polypeptide using standard molecular biological and recombinant DNA techniques.

This invention further includes the T-cell receptors or analogs thereof having substantially the same function or activity as the T-cell receptors of this invention which recognize or bind tumor polypeptides. Such receptors
10 include, but are not limited to, a fragment of the receptor, or a substitution, addition or deletion mutant of a T-cell receptor provided herein. This invention also encompasses polypeptides or peptides that are substantially homologous to the T-cell receptors provided herein or that retain substantially the same activity. The term "analog" includes any protein or polypeptide having an amino
15 acid residue sequence substantially identical to the T-cell receptors provided herein in which one or more residues, preferably no more than 5 residues, more preferably no more than 25 residues have been conservatively substituted with a functionally similar residue and which displays the functional aspects of the T-cell receptor as described herein.

20 The present invention further provides for suitable mammalian host cells, for example, non-specific T cells, that are transfected with a polynucleotide encoding TCRs specific for a polypeptide described herein, thereby rendering the host cell specific for the polypeptide. The α and β chains of the TCR may be contained on separate expression vectors or alternatively,
25 on a single expression vector that also contains an internal ribosome entry site (IRES) for cap-independent translation of the gene downstream of the IRES. Said host cells expressing TCRs specific for the polypeptide may be used, for example, for adoptive immunotherapy of WT1-associated cancer as discussed further below.

30 In further aspects of the present invention, cloned TCRs specific for a polypeptide recited herein may be used in a kit for the diagnosis of WT1-

- associated cancer. For example, the nucleic acid sequence or portions thereof, of tumor-specific TCRs can be used as probes or primers for the detection of expression of the rearranged genes encoding the specific TCR in a biological sample. Therefore, the present invention further provides for an assay for
- 5 detecting messenger RNA or DNA encoding the TCR specific for a polypeptide.

Peptide-MHC Tetrameric Complexes

- The present invention, in another aspect, provides peptide-MHC tetrameric complexes (tetramers) specific for T cells that recognize a polypeptide disclosed herein, or for a variant or derivative thereof. In one
- 10 embodiment, tetramers may be used in the detection of WT1 specific T-cells. Tetramers may be used in monitoring WT1 specific immune responses, early detection of WT1 associated malignancies and for monitoring minimal residual disease. Tetramer staining is typically carried out with flow cytometric analysis and can be used to identify groups within a patient population suffering from a
- 15 WT1 associated disease at a higher risk for relapse or disease progression.

Pharmaceutical Compositions

- In additional embodiments, the present invention concerns formulation of one or more of the polynucleotide, polypeptide, T-cell, TCR, and/or antibody compositions disclosed herein in pharmaceutically-acceptable
- 20 carriers for administration to a cell or an animal, either alone, or in combination with one or more other modalities of therapy.

- It will be understood that, if desired, a composition as disclosed herein may be administered in combination with other agents as well, such as, *e.g.*, other proteins or polypeptides or various pharmaceutically-active agents.
- 25 In fact, there is virtually no limit to other components that may also be included, given that the additional agents do not cause a significant adverse effect upon contact with the target cells or host tissues. The compositions may thus be delivered along with various other agents as required in the particular instance. Such compositions may be purified from host cells or other biological sources,

or alternatively may be chemically synthesized as described herein. Likewise, such compositions may further comprise substituted or derivatized RNA or DNA compositions.

Therefore, in another aspect of the present invention,

- 5 pharmaceutical compositions are provided comprising one or more of the polynucleotide, polypeptide, antibody, TCR, and/or T-cell compositions described herein in combination with a physiologically acceptable carrier. In certain preferred embodiments, the pharmaceutical compositions of the invention comprise immunogenic polynucleotide and/or polypeptide
- 10 compositions of the invention for use in prophylactic and therapeutic vaccine applications. Vaccine preparation is generally described in, for example, M.F. Powell and M.J. Newman, eds., "Vaccine Design (the subunit and adjuvant approach)," Plenum Press (NY, 1995). Generally, such compositions will comprise one or more polynucleotide and/or polypeptide compositions of the
- 15 present invention in combination with one or more immunostimulants.

- It will be apparent that any of the pharmaceutical compositions described herein can contain pharmaceutically acceptable salts of the polynucleotides and polypeptides of the invention. Such salts can be prepared, for example, from pharmaceutically acceptable non-toxic bases, including
- 20 organic bases (e.g., salts of primary, secondary and tertiary amines and basic amino acids) and inorganic bases (e.g., sodium, potassium, lithium, ammonium, calcium and magnesium salts).

- In another embodiment, illustrative immunogenic compositions, e.g., vaccine compositions, of the present invention comprise DNA encoding
- 25 one or more of the polypeptides as described above, such that the polypeptide is generated *in situ*. As noted above, the polynucleotide may be administered within any of a variety of delivery systems known to those of ordinary skill in the art. Indeed, numerous gene delivery techniques are well known in the art, such as those described by Rolland, *Crit. Rev. Therap. Drug Carrier Systems*
- 30 15:143-198, 1998, and references cited therein. Appropriate polynucleotide expression systems will, of course, contain the necessary regulatory DNA

regulatory sequences for expression in a patient (such as a suitable promoter and terminating signal). Alternatively, bacterial delivery systems may involve the administration of a bacterium (such as *Bacillus-Calmette-Guérin*) that expresses an immunogenic portion of the polypeptide on its cell surface or
5 secretes such an epitope.

Therefore, in certain embodiments, polynucleotides encoding immunogenic polypeptides described herein are introduced into suitable mammalian host cells for expression using any of a number of known viral-based systems. In one illustrative embodiment, retroviruses provide a
10 convenient and effective platform for gene delivery systems. A selected nucleotide sequence encoding a polypeptide of the present invention can be inserted into a vector and packaged in retroviral particles using techniques known in the art. The recombinant virus can then be isolated and delivered to a subject. A number of illustrative retroviral systems have been described (*e.g.*,
15 U.S. Pat. No. 5,219,740; Miller and Rosman (1989) *BioTechniques* 7:980-990; Miller, A. D. (1990) *Human Gene Therapy* 1:5-14; Scarpa et al. (1991) *Virology* 180:849-852; Burns et al. (1993) *Proc. Natl. Acad. Sci. USA* 90:8033-8037; and Boris-Lawrie and Temin (1993) *Cur. Opin. Genet. Develop.* 3:102-109.

In addition, a number of illustrative adenovirus-based systems
20 have also been described. Unlike retroviruses which integrate into the host genome, adenoviruses persist extrachromosomally thus minimizing the risks associated with insertional mutagenesis (Haj-Ahmad and Graham (1986) *J. Virol.* 57:267-274; Bett et al. (1993) *J. Virol.* 67:5911-5921; Mittereder et al. (1994) *Human Gene Therapy* 5:717-729; Seth et al. (1994) *J. Virol.* 68:933-
25 940; Barr et al. (1994) *Gene Therapy* 1:51-58; Berkner, K. L. (1988) *BioTechniques* 6:616-629; and Rich et al. (1993) *Human Gene Therapy* 4:461-476).

Various adeno-associated virus (AAV) vector systems have also been developed for polynucleotide delivery. AAV vectors can be readily
30 constructed using techniques well known in the art. See, *e.g.*, U.S. Pat. Nos. 5,173,414 and 5,139,941; International Publication Nos. WO 92/01070 and

- WO 93/03769; Lebkowski et al. (1988) *Molec. Cell. Biol.* 8:3988-3996; Vincent et al. (1990) *Vaccines 90* (Cold Spring Harbor Laboratory Press); Carter, B. J. (1992) *Current Opinion in Biotechnology* 3:533-539; Muzyczka, N. (1992) *Current Topics in Microbiol. and Immunol.* 158:97-129; Kotin, R. M. (1994) *Human Gene Therapy* 5:793-801; Shelling and Smith (1994) *Gene Therapy* 1:165-169; and Zhou et al. (1994) *J. Exp. Med.* 179:1867-1875.

Additional viral vectors useful for delivering the polynucleotides encoding polypeptides of the present invention by gene transfer include those derived from the pox family of viruses, such as vaccinia virus and avian poxvirus. By way of example, vaccinia virus recombinants expressing the novel molecules can be constructed as follows. The DNA encoding a polypeptide is first inserted into an appropriate vector so that it is adjacent to a vaccinia promoter and flanking vaccinia DNA sequences, such as the sequence encoding thymidine kinase (TK). This vector is then used to transfect cells which are simultaneously infected with vaccinia. Homologous recombination serves to insert the vaccinia promoter plus the gene encoding the polypeptide of interest into the viral genome. The resulting TK.sup.(-) recombinant can be selected by culturing the cells in the presence of 5-bromodeoxyuridine and picking viral plaques resistant thereto.

- A vaccinia-based infection/transfection system can be conveniently used to provide for inducible, transient expression or coexpression of one or more polypeptides described herein in host cells of an organism. In this particular system, cells are first infected *in vitro* with a vaccinia virus recombinant that encodes the bacteriophage T7 RNA polymerase. This polymerase displays exquisite specificity in that it only transcribes templates bearing T7 promoters. Following infection, cells are transfected with the polynucleotide or polynucleotides of interest, driven by a T7 promoter. The polymerase expressed in the cytoplasm from the vaccinia virus recombinant transcribes the transfected DNA into RNA which is then translated into polypeptide by the host translational machinery. The method provides for high level, transient, cytoplasmic production of large quantities of RNA and its

translation products. See, e.g., Elroy-Stein and Moss, Proc. Natl. Acad. Sci. USA (1990) 87:6743-6747; Fuerst et al. Proc. Natl. Acad. Sci. USA (1986) 83:8122-8126.

- Alternatively, avipoxviruses, such as the fowlpox and canarypox viruses, can also be used to deliver the coding sequences of interest.
- 5 Recombinant avipox viruses, expressing immunogens from mammalian pathogens, are known to confer protective immunity when administered to non-avian species. The use of an Avipox vector is particularly desirable in human and other mammalian species since members of the Avipox genus can only
- 10 productively replicate in susceptible avian species and therefore are not infective in mammalian cells. Methods for producing recombinant Avipoxviruses are known in the art and employ genetic recombination, as described above with respect to the production of vaccinia viruses. See, e.g., WO 91/12882; WO 89/03429; and WO 92/03545. A number of pox viruses
- 15 have been developed as live viral vectors for the expression of heterologous proteins (Cepko et al., Cell 37:1053-1062 (1984); Morin et al., Proc. Natl. Acad. Sci. USA 84:4626-4630 (1987); Lowe et al., Proc. Natl. Acad. Sci. USA, 84:3896-3900 (1987); Panicali & Paoletti, Proc. Natl. Acad. Sci. USA, 79:4927-4931 (1982); Machett et al., Proc. Natl. Acad. Sci. USA, 79:7415-7419 (1982)).
- 20 Representative fowlpox and swinepox virus are available through the ATCC under accession numbers VR-229 and VR-363, respectively. A recombinant vaccinia-CEA is available through the ATCC under accession number VR2323. Other illustrative viral vectors also include, but are not limited to, those described by Therion Biologics (Cambridge, MA, USA), for example, in
- 25 U.S. Patent Nos. 6,051,410, 5,858,726, 5,656,465, 5,804,196, 5,747,324, 6,319,496, 6,165,460.

- Any of a number of alphavirus vectors can also be used for delivery of polynucleotide compositions of the present invention, such as those vectors described in U.S. Patent Nos. 5,843,723; 6,015,686; 6,008,035 and
- 30 6,015,694. Certain vectors based on Venezuelan Equine Encephalitis (VEE)

can also be used, illustrative examples of which can be found in U.S. Patent Nos. 5,505,947 and 5,643,576.

- Moreover, molecular conjugate vectors, such as the adenovirus chimeric vectors described in Michael et al. *J. Biol. Chem.* (1993) 268:6866-6869 and Wagner et al. *Proc. Natl. Acad. Sci. USA* (1992) 89:6099-6103, can also be used for gene delivery under the invention.

- Additional illustrative information on these and other known viral-based delivery systems can be found, for example, in Fisher-Hoch et al., *Proc. Natl. Acad. Sci. USA* 86:317-321, 1989; Flexner et al., *Ann. N.Y. Acad. Sci.* 569:86-103, 1989; Flexner et al., *Vaccine* 8:17-21, 1990; U.S. Patent Nos. 4,603,112, 4,769,330, and 5,017,487; WO 89/01973; U.S. Patent No. 4,777,127; GB 2,200,651; EP 0,345,242; WO 91/02805; Berkner, *Biotechniques* 6:616-627, 1988; Rosenfeld et al., *Science* 252:431-434, 1991; Kolls et al., *Proc. Natl. Acad. Sci. USA* 91:215-219, 1994; Kass-Eisler et al., *Proc. Natl. Acad. Sci. USA* 90:11498-11502, 1993; Guzman et al., *Circulation* 88:2838-2848, 1993; and Guzman et al., *Cir. Res.* 73:1202-1207, 1993.

- As would be readily appreciated by the skilled artisan, any number of additional components may be present in a DNA or retroviral vector expressing a WT1 polypeptide or any portion thereof, as described herein. For example, an expression vector for delivery of a polynucleotide or peptide of the present invention may include any number of a variety of costimulatory molecules, including, but not limited to CD28, B7-1, ICAM-1, and LFA-3. A delivery vector may also include any number of cytokines, for example IFN- γ , GM-CSF, or IL-2. In one illustrative embodiment, a recombinant viral vector, e.g. a vaccinia or fowlpox vector, includes B7-1, ICAM-1, and LFA-3.

- The present invention also comprises the use of any combination of the DNA and/or viral vectors described herein for use in the treatment of malignancies associated with the expression of WT1. In one illustrative embodiment, a recombinant vaccinia viral vector is administered to an animal or human patient afflicted with a WT1-associated malignancy, followed by administration of a recombinant fowlpox vector. In another embodiment of the

present invention, the recombinant fowlpox is administered twice following administration of the vaccinia vector (e.g. a prime/boost/boost vaccination regimen).

5 In certain embodiments, a polynucleotide may be integrated into the genome of a target cell. This integration may be in the specific location and orientation *v/a* homologous recombination (gene replacement) or it may be integrated in a random, non-specific location (gene augmentation). In yet further embodiments, the polynucleotide may be stably maintained in the cell
10 as a separate, episomal segment of DNA. Such polynucleotide segments or "episomes" encode sequences sufficient to permit maintenance and replication independent of or in synchronization with the host cell cycle. The manner in which the expression construct is delivered to a cell and where in the cell the polynucleotide remains is dependent on the type of expression construct
15 employed.

 In another embodiment of the invention, a polynucleotide is administered/delivered as "naked" DNA, for example as described in Ulmer et al., *Science* 259:1745-1749, 1993 and reviewed by Cohen, *Science* 259:1691-1692, 1993. The uptake of naked DNA may be increased by coating the DNA
20 onto biodegradable beads, which are efficiently transported into the cells.

 In still another embodiment, a composition of the present invention can be delivered via a particle bombardment approach, many of which have been described. In one illustrative example, gas-driven particle acceleration can be achieved with devices such as those manufactured by
25 Powderject Pharmaceuticals PLC (Oxford, UK) and Powderject Vaccines Inc. (Madison, WI), some examples of which are described in U.S. Patent Nos. 5,846,796; 6,010,478; 5,865,796; 5,584,807; and EP Patent No. 0500 799. This approach offers a needle-free delivery approach wherein a dry powder formulation of microscopic particles, such as polynucleotide or polypeptide
30 particles, are accelerated to high speed within a helium gas jet generated by a hand held device, propelling the particles into a target tissue of interest.

In a related embodiment, other devices and methods that may be useful for gas-driven needle-less injection of compositions of the present invention include those provided by Bioject, Inc. (Portland, OR), some examples of which are described in U.S. Patent Nos. 4,790,824; 5,064,413;

5 5,312,335; 5,383,851; 5,399,163; 5,520,639 and 5,993,412.

According to another embodiment, the pharmaceutical compositions described herein will comprise one or more immunostimulants in addition to the immunogenic polynucleotide, polypeptide, antibody, T-cell, TCR, and/or APC compositions of this invention. An immunostimulant refers to essentially any substance that enhances or potentiates an immune response (antibody and/or cell-mediated) to an exogenous antigen. One preferred type of immunostimulant comprises an adjuvant. Many adjuvants contain a substance designed to protect the antigen from rapid catabolism, such as aluminum hydroxide or mineral oil, and a stimulator of immune responses, such as lipid A, *Bordetella pertussis* or *Mycobacterium tuberculosis* derived proteins. Certain adjuvants are commercially available as, for example, Freund's Incomplete Adjuvant and Complete Adjuvant (Difco Laboratories, Detroit, MI); Merck Adjuvant 65 (Merck and Company, Inc., Rahway, NJ); AS-2 (SmithKline Beecham, Philadelphia, PA); aluminum salts such as aluminum hydroxide gel (alum) or aluminum phosphate; salts of calcium, iron or zinc; an insoluble suspension of acylated tyrosine; acylated sugars; cationically or anionically derivatized polysaccharides; polyphosphazenes; biodegradable microspheres; monophosphoryl lipid A and quil A. Cytokines, such as GM-CSF, interleukin-2, -7, -12, and other like growth factors, may also be used as adjuvants.

Within certain embodiments of the invention, the adjuvant composition is preferably one that induces an immune response predominantly of the Th1 type. High levels of Th1-type cytokines (e.g., IFN- γ , TNF α , IL-2 and IL-12) tend to favor the induction of cell mediated immune responses to an administered antigen. In contrast, high levels of Th2-type cytokines (e.g., IL-4, IL-5, IL-6 and IL-10) tend to favor the induction of humoral immune responses. Following application of a vaccine as provided herein, a patient will support an

immune response that includes Th1- and Th2-type responses. Within a preferred embodiment, in which a response is predominantly Th1-type, the level of Th1-type cytokines will increase to a greater extent than the level of Th2-type cytokines. The levels of these cytokines may be readily assessed using standard assays. For a review of the families of cytokines, see Mosmann and Coffman, Ann. Rev. Immunol. 7:145-173, 1989.

Certain preferred adjuvants for eliciting a predominantly Th1-type response include, for example, a combination of monophosphoryl lipid A, preferably 3-de-O-acylated monophosphoryl lipid A, together with an aluminum salt. MPL[®] adjuvants are available from Corixa Corporation (Seattle, WA; see, for example, US Patent Nos. 4,436,727; 4,877,611; 4,866,034 and 4,912,094). CpG-containing oligonucleotides (in which the CpG dinucleotide is unmethylated) also induce a predominantly Th1 response. Such oligonucleotides are well known and are described, for example, in WO 96/02555, WO 99/33488 and U.S. Patent Nos. 6,008,200 and 5,856,462. Immunostimulatory DNA sequences are also described, for example, by Sato et al., *Science* 273:352, 1996. Another preferred adjuvant comprises a saponin, such as Quil A, or derivatives thereof, including QS21 and QS7 (Aquila Biopharmaceuticals Inc., Framingham, MA); Escin; Digitonin; or *Gypsophila* or *Chenopodium quinoa* saponins. Other preferred formulations include more than one saponin in the adjuvant combinations of the present invention, for example combinations of at least two of the following group comprising QS21, QS7, Quil A, β -escin, or digitonin.

Alternatively the saponin formulations may be combined with vaccine vehicles composed of chitosan or other polycationic polymers, polylactide and polylactide-co-glycolide particles, poly-N-acetyl glucosamine-based polymer matrix, particles composed of polysaccharides or chemically modified polysaccharides, liposomes and lipid-based particles, particles composed of glycerol monoesters, etc. The saponins may also be formulated in the presence of cholesterol to form particulate structures such as liposomes or ISCOMs. Furthermore, the saponins may be formulated together with a

- polyoxyethylene ether or ester, in either a non-particulate solution or suspension, or in a particulate structure such as a paucilamellar liposome or ISCOM. The saponins may also be formulated with excipients such as Carbopol[®] to increase viscosity, or may be formulated in a dry powder form with
- 5 a powder excipient such as lactose.

- In one preferred embodiment, the adjuvant system includes the combination of a monophosphoryl lipid A and a saponin derivative, such as the combination of QS21 and 3D-MPL[®] adjuvant, as described in WO 94/00153, or a less reactogenic composition where the QS21 is quenched with cholesterol,
- 10 as described in WO 96/33739. Other preferred formulations comprise an oil-in-water emulsion and tocopherol. Another particularly preferred adjuvant formulation employing QS21, 3D-MPL[®] adjuvant and tocopherol in an oil-in-water emulsion is described in WO 95/17210.

- Another enhanced adjuvant system involves the combination of a
- 15 CpG-containing oligonucleotide and a saponin derivative particularly the combination of CpG and QS21 is disclosed in WO 00/09159. Preferably the formulation additionally comprises an oil in water emulsion and tocopherol.

- Additional illustrative adjuvants for use in the pharmaceutical compositions of the invention include Montanide ISA 720 (Seppic, France),
- 20 SAF (Chiron, California, United States), ISCOMS (CSL), MF-59 (Chiron), the SBAS series of adjuvants (*e.g.*, SBAS-2 or SBAS-4, available from SmithKline Beecham, Rixensart, Belgium), Detox (Enhanzyn[®]) (Corixa, Hamilton, MT), RC-529 (Corixa, Hamilton, MT) and other aminoalkyl glucosaminide 4-phosphates (AGPs), such as those described in pending U.S. Patent Application Serial
- 25 Nos. 08/853,826 and 09/074,720, and in U.S. Patent Nos. 6,303,347 the disclosures of which are incorporated herein by reference in their entireties, and polyoxyethylene ether adjuvants such as those described in WO 99/52549A1. Additional illustrative adjuvants for use in the pharmaceutical compositions of the invention include isotucerosol.

- 30 Other preferred adjuvants include adjuvant molecules of the general formula

(I): $\text{HO}(\text{CH}_2\text{CH}_2\text{O})_n\text{-A-R}$,

wherein, n is 1-50, A is a bond or $-\text{C}(\text{O})-$, R is C_{1-50} alkyl or

Phenyl C_{1-50} alkyl.

- One embodiment of the present invention consists of a vaccine
- 5 formulation comprising a polyoxyethylene ether of general formula (I), wherein n is between 1 and 50, preferably 4-24, most preferably 9; the R component is C_{1-50} , preferably $\text{C}_4\text{-C}_{20}$ alkyl and most preferably C_{12} alkyl, and A is a bond. The concentration of the polyoxyethylene ethers should be in the range 0.1-20%, preferably from 0.1-10%, and most preferably in the range 0.1-1%.
- 10 Preferred polyoxyethylene ethers are selected from the following group: polyoxyethylene-9-lauryl ether, polyoxyethylene-9-stearyl ether, polyoxyethylene-8-stearyl ether, polyoxyethylene-4-lauryl ether, polyoxyethylene-35-lauryl ether, and polyoxyethylene-23-lauryl ether. Polyoxyethylene ethers such as polyoxyethylene lauryl ether are described in
- 15 the Merck index (12th edition: entry 7717). These adjuvant molecules are described in WO 99/52549.

The polyoxyethylene ether according to the general formula (I) above may, if desired, be combined with another adjuvant. For example, a preferred adjuvant combination is preferably with CpG as described in the

20 pending UK patent application GB 9820956.2.

According to another embodiment of this invention, an immunogenic composition described herein is delivered to a host via antigen presenting cells (APCs), such as dendritic cells, macrophages, B cells, monocytes and other cells that may be engineered to be efficient APCs. Such

25 cells may, but need not, be genetically modified to increase the capacity for presenting the antigen, to improve activation and/or maintenance of the T cell response, to have anti-tumor effects *per se* and/or to be immunologically compatible with the receiver (*i.e.*, matched HLA haplotype). APCs may generally be isolated from any of a variety of biological fluids and organs,

30 including tumor and peritumoral tissues, and may be autologous, allogeneic, syngeneic or xenogeneic cells.

Certain preferred embodiments of the present invention use dendritic cells or progenitors thereof as antigen-presenting cells. Dendritic cells are highly potent APCs (Banchereau and Steinman, *Nature* 392:245-251, 1998) and have been shown to be effective as a physiological adjuvant for
5 eliciting prophylactic or therapeutic antitumor immunity (see Timmerman and Levy, *Ann. Rev. Med.* 50:507-529, 1999). In general, dendritic cells may be identified based on their typical shape (stellate *in situ*, with marked cytoplasmic processes (dendrites) visible *in vitro*), their ability to take up, process and present antigens with high efficiency and their ability to activate naïve T cell
10 responses. Dendritic cells may, of course, be engineered to express specific cell-surface receptors or ligands that are not commonly found on dendritic cells *in vivo* or *ex vivo*, and such modified dendritic cells are contemplated by the present invention. As an alternative to dendritic cells, secreted vesicles antigen-loaded dendritic cells (called exosomes) may be used within a vaccine
15 (see Zitvogel et al., *Nature Med.* 4:594-600, 1998).

Dendritic cells and progenitors may be obtained from peripheral blood, bone marrow, tumor-infiltrating cells, peritumoral tissues-infiltrating cells, lymph nodes, spleen, skin, umbilical cord blood or any other suitable tissue or fluid. For example, dendritic cells may be differentiated *ex vivo* by adding a
20 combination of cytokines such as GM-CSF, IL-4, IL-13 and/or TNF α to cultures of monocytes harvested from peripheral blood. Alternatively, CD34 positive cells harvested from peripheral blood, umbilical cord blood or bone marrow may be differentiated into dendritic cells by adding to the culture medium combinations of GM-CSF, IL-3, TNF α , CD40 ligand, LPS, fit3 ligand and/or
25 other compound(s) that induce differentiation, maturation and proliferation of dendritic cells.

Dendritic cells are conveniently categorized as "immature" and "mature" cells, which allows a simple way to discriminate between two well characterized phenotypes. However, this nomenclature should not be
30 construed to exclude all possible intermediate stages of differentiation. Immature dendritic cells are characterized as APC with a high capacity for

- antigen uptake and processing, which correlates with the high expression of Fcγ receptor and mannose receptor. The mature phenotype is typically characterized by a lower expression of these markers, but a high expression of cell surface molecules responsible for T cell activation such as class I and class II MHC, adhesion molecules (e.g., CD54 and CD11) and costimulatory molecules (e.g., CD40, CD80, CD86 and 4-1BB).

- APCs may generally be transfected with a polynucleotide of the invention (or portion or other variant thereof) such that the encoded polypeptide, or an immunogenic portion thereof, is expressed on the cell surface. Such transfection may take place *ex vivo*, and a pharmaceutical composition comprising such transfected cells may then be used for therapeutic purposes, as described herein. Alternatively, a gene delivery vehicle that targets a dendritic or other antigen presenting cell may be administered to a patient, resulting in transfection that occurs *in vivo*. *In vivo* and *ex vivo* transfection of dendritic cells, for example, may generally be performed using any methods known in the art, such as those described in WO 97/24447, or the gene gun approach described by Mahvi et al., *Immunology and cell Biology* 75:456-460, 1997. Antigen loading of dendritic cells may be achieved by incubating dendritic cells or progenitor cells with the tumor polypeptide, DNA (naked or within a plasmid vector) or RNA; or with antigen-expressing recombinant bacterium or viruses (e.g., vaccinia, fowlpox, adenovirus or lentivirus vectors). Prior to loading, the polypeptide may be covalently conjugated to an immunological partner that provides T cell help (e.g., a carrier molecule). Alternatively, a dendritic cell may be pulsed with a non-conjugated immunological partner, separately or in the presence of the polypeptide.

- While any suitable carrier known to those of ordinary skill in the art may be employed in the pharmaceutical compositions of this invention, the type of carrier will typically vary depending on the mode of administration.
- Compositions of the present invention may be formulated for any appropriate manner of administration, including for example, topical, oral, nasal, mucosal,

intravenous, intracranial, intraperitoneal, subcutaneous and intramuscular administration.

- Carriers for use within such pharmaceutical compositions are biocompatible, and may also be biodegradable. In certain embodiments, the formulation preferably provides a relatively constant level of active component release. In other embodiments, however, a more rapid rate of release immediately upon administration may be desired. The formulation of such compositions is well within the level of ordinary skill in the art using known techniques. Illustrative carriers useful in this regard include microparticles of poly(lactide-co-glycolide), polyacrylate, latex, starch, cellulose, dextran and the like. Other illustrative delayed-release carriers include supramolecular biovectors, which comprise a non-liquid hydrophilic core (e.g., a cross-linked polysaccharide or oligosaccharide) and, optionally, an external layer comprising an amphiphilic compound, such as a phospholipid (see e.g., U.S. Patent No. 5,151,254 and PCT applications WO 94/20078, WO/94/23701 and WO 96/06638). The amount of active compound contained within a sustained release formulation depends upon the site of implantation, the rate and expected duration of release and the nature of the condition to be treated or prevented.
- In another illustrative embodiment, biodegradable microspheres (e.g., polylactate polyglycolate) are employed as carriers for the compositions of this invention. Suitable biodegradable microspheres are disclosed, for example, in U.S. Patent Nos. 4,897,268; 5,075,109; 5,928,647; 5,811,128; 5,820,883; 5,853,763; 5,814,344, 5,407,609 and 5,942,252. Modified hepatitis B core protein carrier systems, such as described in WO/99 40934, and references cited therein, will also be useful for many applications. Another illustrative carrier/delivery system employs a carrier comprising particulate-protein complexes, such as those described in U.S. Patent No. 5,928,647, which are capable of inducing a class I-restricted cytotoxic T lymphocyte responses in a host.

In another illustrative embodiment, calcium phosphate core particles are employed as carriers, vaccine adjuvants, or as controlled release matrices for the compositions of this invention. Exemplary calcium phosphate particles are disclosed, for example, in published patent application No.

5 WO/0046147.

The pharmaceutical compositions of the invention will often further comprise one or more buffers (e.g., neutral buffered saline or phosphate buffered saline), carbohydrates (e.g., glucose, mannose, sucrose or dextrans), mannitol, proteins, polypeptides or amino acids such as glycine, antioxidants, 10 bacteriostats, chelating agents such as EDTA or glutathione, adjuvants (e.g., aluminum hydroxide), solutes that render the formulation isotonic, hypotonic or weakly hypertonic with the blood of a recipient, suspending agents, thickening agents and/or preservatives. Alternatively, compositions of the present invention may be formulated as a lyophilizate.

15 The pharmaceutical compositions described herein may be presented in unit-dose or multi-dose containers, such as sealed ampoules or vials. Such containers are typically sealed in such a way to preserve the sterility and stability of the formulation until use. In general, formulations may be stored as suspensions, solutions or emulsions in oily or aqueous vehicles. 20 Alternatively, a pharmaceutical composition may be stored in a freeze-dried condition requiring only the addition of a sterile liquid carrier immediately prior to use.

The development of suitable dosing and treatment regimens for using the particular compositions described herein in a variety of treatment 25 regimens, including e.g., oral, parenteral, intravenous, intranasal, and intramuscular administration and formulation, is well known in the art, some of which are briefly discussed below for general purposes of illustration.

In certain applications, the pharmaceutical compositions disclosed herein may be delivered via oral administration to an animal. As 30 such, these compositions may be formulated with an inert diluent or with an assimilable edible carrier, or they may be enclosed in hard- or soft-shell gelatin

capsule, or they may be compressed into tablets, or they may be incorporated directly with the food of the diet.

- The active compounds may even be incorporated with excipients and used in the form of ingestible tablets, buccal tables, troches, capsules, elixirs, suspensions, syrups, wafers, and the like (see, for example, Mathiowitz *et al.*, *Nature* 1997 Mar 27;386(6623):410-4; Hwang *et al.*, *Crit Rev Ther Drug Carrier Syst* 1998;15(3):243-84; U. S. Patent 5,641,515; U. S. Patent 5,580,579 and U. S. Patent 5,792,451). Tablets, troches, pills, capsules and the like may also contain any of a variety of additional components, for example, a binder, such as gum tragacanth, acacia, cornstarch, or gelatin; excipients, such as dicalcium phosphate; a disintegrating agent, such as corn starch, potato starch, alginic acid and the like; a lubricant, such as magnesium stearate; and a sweetening agent, such as sucrose, lactose or saccharin may be added or a flavoring agent, such as peppermint, oil of wintergreen, or cherry flavoring.
- When the dosage unit form is a capsule, It may contain, in addition to materials of the above type, a liquid carrier. Various other materials may be present as coatings or to otherwise modify the physical form of the dosage unit. For instance, tablets, pills, or capsules may be coated with shellac, sugar, or both. Of course, any material used in preparing any dosage unit form should be pharmaceutically pure and substantially non-toxic in the amounts employed. In addition, the active compounds may be incorporated into sustained-release preparation and formulations.

- Typically, these formulations will contain at least about 0.1 % of the active compound or more, although the percentage of the active ingredient(s) may, of course, be varied and may conveniently be between about 1 or 2% and about 60% or 70% or more of the weight or volume of the total formulation. Naturally, the amount of active compound(s) in each therapeutically useful composition may be prepared in such a way that a suitable dosage will be obtained in any given unit dose of the compound.
- Factors such as solubility, bioavailability, biological half-life, route of administration, product shelf life, as well as other pharmacological

considerations will be contemplated by one skilled in the art of preparing such pharmaceutical formulations, and as such, a variety of dosages and treatment regimens may be desirable.

For oral administration the compositions of the present invention
5 may alternatively be incorporated with one or more excipients in the form of a mouthwash, dentifrice, buccal tablet, oral spray, or sublingual orally-administered formulation. Alternatively, the active ingredient may be incorporated into an oral solution such as one containing sodium borate, glycerin and potassium bicarbonate, or dispersed in a dentifrice, or added in a
10 therapeutically-effective amount to a composition that may include water, binders, abrasives, flavoring agents, foaming agents, and humectants. Alternatively the compositions may be fashioned into a tablet or solution form that may be placed under the tongue or otherwise dissolved in the mouth.

In certain circumstances it will be desirable to deliver the
15 pharmaceutical compositions disclosed herein parenterally, intravenously, intramuscularly, or even intraperitoneally. Such approaches are well known to the skilled artisan, some of which are further described, for example, in U. S. Patent 5,543,158; U. S. Patent 5,641,515 and U. S. Patent 5,399,363. In certain embodiments, solutions of the active compounds as free base or
20 pharmacologically acceptable salts may be prepared in water suitably mixed with a surfactant, such as hydroxypropylcellulose. Dispersions may also be prepared in glycerol, liquid polyethylene glycols, and mixtures thereof and in oils. Under ordinary conditions of storage and use, these preparations generally will contain a preservative to prevent the growth of microorganisms.

25 Illustrative pharmaceutical forms suitable for injectable use include sterile aqueous solutions or dispersions and sterile powders for the extemporaneous preparation of sterile injectable solutions or dispersions (for example, see U. S. Patent 5,466,468). In all cases the form must be sterile and must be fluid to the extent that easy syringability exists. It must be stable
30 under the conditions of manufacture and storage and must be preserved against the contaminating action of microorganisms, such as bacteria and

fungi. The carrier can be a solvent or dispersion medium containing, for example, water, ethanol, polyol (e.g., glycerol, propylene glycol, and liquid polyethylene glycol, and the like), suitable mixtures thereof, and/or vegetable oils. Proper fluidity may be maintained, for example, by the use of a coating, such as lecithin, by the maintenance of the required particle size in the case of dispersion and/or by the use of surfactants. The prevention of the action of microorganisms can be facilitated by various antibacterial and antifungal agents, for example, parabens, chlorobutanol, phenol, sorbic acid, thimerosal, and the like. In many cases, it will be preferable to include isotonic agents, for example, sugars or sodium chloride. Prolonged absorption of the injectable compositions can be brought about by the use in the compositions of agents delaying absorption, for example, aluminum monostearate and gelatin.

In one embodiment, for parenteral administration in an aqueous solution, the solution should be suitably buffered if necessary and the liquid diluent first rendered isotonic with sufficient saline or glucose. These particular aqueous solutions are especially suitable for intravenous, intramuscular, subcutaneous and intraperitoneal administration. In this connection, a sterile aqueous medium that can be employed will be known to those of skill in the art in light of the present disclosure. For example, one dosage may be dissolved in 1 ml of isotonic NaCl solution and either added to 1000 ml of hypodermodysis fluid or injected at the proposed site of infusion, (see for example, "Remington's Pharmaceutical Sciences" 15th Edition, pages 1035-1038 and 1570-1580). Some variation in dosage will necessarily occur depending on the condition of the subject being treated. Moreover, for human administration, preparations will of course preferably meet sterility, pyrogenicity, and the general safety and purity standards as required by FDA Office of Biologics standards.

In another embodiment of the invention, the compositions disclosed herein may be formulated in a neutral or salt form. Illustrative pharmaceutically-acceptable salts include the acid addition salts (formed with the free amino groups of the protein) and which are formed with inorganic acids

- such as, for example, hydrochloric or phosphoric acids, or such organic acids as acetic, oxalic, tartaric, mandelic, and the like. Salts formed with the free carboxyl groups can also be derived from inorganic bases such as, for example, sodium, potassium, ammonium, calcium, or ferric hydroxides, and
- 5 such organic bases as isopropylamine, trimethylamine, histidine, procaine and the like. Upon formulation, solutions will be administered in a manner compatible with the dosage formulation and in such amount as is therapeutically effective.

- The carriers can further comprise any and all solvents, dispersion
- 10 media, vehicles, coatings, diluents, antibacterial and antifungal agents, isotonic and absorption delaying agents, buffers, carrier solutions, suspensions, colloids, and the like. The use of such media and agents for pharmaceutical active substances is well known in the art. Except insofar as any conventional media or agent is incompatible with the active ingredient, its use in the
- 15 therapeutic compositions is contemplated. Supplementary active ingredients can also be incorporated into the compositions. The phrase "pharmaceutically-acceptable" refers to molecular entities and compositions that do not produce an allergic or similar untoward reaction when administered to a human.

- 20 In certain embodiments, the pharmaceutical compositions may be delivered by intranasal sprays, inhalation, and/or other aerosol delivery vehicles. Methods for delivering genes, nucleic acids, and peptide compositions directly to the lungs *via* nasal aerosol sprays has been described, *e.g.*, in U. S. Patent 5,756,353 and U. S. Patent 5,804,212. Likewise, the
- 25 delivery of drugs using intranasal microparticle resins (Takenaga *et al.*, J Controlled Release 1998 Mar 2;52(1-2):81-7) and lysophosphatidyl-glycerol compounds (U. S. Patent 5,725,871) are also well-known in the pharmaceutical arts. Likewise, illustrative transmucosal drug delivery in the form of a polytetrafluoroethylene support matrix is described in U. S. Patent 5,780,045.

- 30 In certain embodiments, liposomes, nanocapsules, microparticles, lipid particles, vesicles, and the like, are used for the introduction of the

compositions of the present invention into suitable host cells/organisms. In particular, the compositions of the present invention may be formulated for delivery either encapsulated in a lipid particle, a liposome, a vesicle, a nanosphere, or a nanoparticle or the like. Alternatively, compositions of the present invention can be bound, either covalently or non-covalently, to the surface of such carrier vehicles.

The formation and use of liposome and liposome-like preparations as potential drug carriers is generally known to those of skill in the art (see for example, Lasic, Trends Biotechnol 1998 Jul;16(7):307-21; Takakura, Nippon Rinsho 1998 Mar;56(3):691-5; Chandran *et al.*, Indian J Exp Biol. 1997 Aug;35(8):801-9; Margalit, Crit Rev Ther Drug Carrier Syst. 1995;12(2-3):233-61; U.S. Patent 5,567,434; U.S. Patent 5,552,157; U.S. Patent 5,565,213; U.S. Patent 5,738,868 and U.S. Patent 5,795,587, each specifically incorporated herein by reference in its entirety).

Liposomes have been used successfully with a number of cell types that are normally difficult to transfect by other procedures, including T cell suspensions, primary hepatocyte cultures and PC 12 cells (Renneisen *et al.*, J Biol Chem. 1990 Sep 25;265(27):16337-42; Muller *et al.*, DNA Cell Biol. 1990 Apr;9(3):221-9). In addition, liposomes are free of the DNA length constraints that are typical of viral-based delivery systems. Liposomes have been used effectively to introduce genes, various drugs, radiotherapeutic agents, enzymes, viruses, transcription factors, allosteric effectors and the like, into a variety of cultured cell lines and animals. Furthermore, the use of liposomes does not appear to be associated with autoimmune responses or unacceptable toxicity after systemic delivery.

In certain embodiments, liposomes are formed from phospholipids that are dispersed in an aqueous medium and spontaneously form multilamellar concentric bilayer vesicles (also termed multilamellar vesicles (MLVs)).

Alternatively, in other embodiments, the invention provides for pharmaceutically-acceptable nanocapsule formulations of the compositions of

the present invention. Nanocapsules can generally entrap compounds in a stable and reproducible way (see, for example, Quintanar-Guerrero *et al.*, Drug Dev Ind Pharm. 1998 Dec;24(12):1113-28). To avoid side effects due to intracellular polymeric overloading, such ultrafine particles (sized around 0.1
5 μm) may be designed using polymers able to be degraded *in vivo*. Such particles can be made as described, for example, by Couvreur *et al.*, Crit Rev Ther Drug Carrier Syst. 1988;5(1):1-20; zur Muhlen *et al.*, Eur J Pharm Biopharm. 1998 Mar;45(2):149-55; Zambaux *et al.* J Controlled Release. 1998 Jan 2;50(1-3):31-40; and U. S. Patent 5,145,684.

10 Therapy of Malignant Diseases

Immunologic approaches to cancer therapy are based on the recognition that cancer cells can often evade the body's defenses against aberrant or foreign cells and molecules, and that these defenses might be therapeutically stimulated to regain the lost ground, e.g. pgs. 623-648 in Klein,
15 Immunology (Wiley-Interscience, New York, 1982). Numerous recent observations that various immune effectors can directly or indirectly inhibit growth of tumors has led to renewed interest in this approach to cancer therapy, e.g. Jager, et al., Oncology 2001;60(1):1-7; Renner, et al., Ann Hematol 2000 Dec;79(12):651-9.

- 20 Four-basic cell types whose function has been associated with antitumor cell immunity and the elimination of tumor cells from the body are: i) B-lymphocytes which secrete immunoglobulins into the blood plasma for identifying and labeling the nonself invader cells; ii) monocytes which secrete the complement proteins that are responsible for lysing and processing the
25 immunoglobulin-coated target invader cells; iii) natural killer lymphocytes having two mechanisms for the destruction of tumor cells, antibody-dependent cellular cytotoxicity and natural killing; and iv) T-lymphocytes possessing antigen-specific receptors and having the capacity to recognize a tumor cell carrying complementary marker molecules (Schreiber, H., 1989, in
30 Fundamental Immunology (ed) W. E. Paul, pp. 923-955).

Cancer immunotherapy generally focuses on inducing humoral immune responses, cellular immune responses, or both. Moreover, it is well established that induction of CD4⁺ T helper cells is necessary in order to secondarily induce either antibodies or cytotoxic CD8⁺ T cells. Polypeptide antigens that are selective or ideally specific for cancer cells, particularly cancer cells associated with WT1 expression, offer a powerful approach for inducing immune responses against cancer associated with WT1 expression, and are an important aspect of the present invention.

In further aspects of the present invention, the compositions and vaccines described herein may be used to inhibit the development of malignant diseases (e.g., progressive or metastatic diseases or diseases characterized by small tumor burden such as minimal residual disease). In general, such methods may be used to prevent, delay or treat a disease associated with WT1 expression. In other words, therapeutic methods provided herein may be used to treat an existing WT1-associated disease, or may be used to prevent or delay the onset of such a disease in a patient who is free of disease or who is afflicted with a disease that is not yet associated with WT1 expression.

As used herein, a disease is "associated with WT1 expression" if diseased cells (e.g., tumor cells) at some time during the course of the disease generate detectably higher levels of a WT1 polypeptide than normal cells of the same tissue. Association of WT1 expression with a malignant disease does not require that WT1 be present on a tumor. For example, overexpression of WT1 may be involved with initiation of a tumor, but the protein expression may subsequently be lost. Alternatively, a malignant disease that is not characterized by an increase in WT1 expression may, at a later time, progress to a disease that is characterized by increased WT1 expression. Accordingly, any malignant disease in which diseased cells formerly expressed, currently express or are expected to subsequently express increased levels of WT1 is considered to be "associated with WT1 expression."

Immunotherapy may be performed using any of a variety of techniques, in which compounds or cells provided herein function to remove

WT1-expressing cells from a patient. Such removal may take place as a result of enhancing or inducing an immune response in a patient specific for WT1 or a cell expressing WT1. Alternatively, WT1-expressing cells may be removed *ex vivo* (e.g., by treatment of autologous bone marrow, peripheral blood or a
5 fraction of bone marrow or peripheral blood). Fractions of bone marrow or peripheral blood may be obtained using any standard technique in the art.

Within such methods, pharmaceutical compositions and vaccines may be administered to a patient. As used herein, a "patient" refers to any warm-blooded animal, preferably a human. A patient may or may not be
10 afflicted with a malignant disease. Accordingly, the above pharmaceutical compositions and vaccines may be used to prevent the onset of a disease (*i.e.*, prophylactically) or to treat a patient afflicted with a disease (*e.g.*, to prevent or delay progression and/or metastasis of an existing disease). A patient afflicted with a disease may have a minimal residual disease (*e.g.*, a low tumor burden
15 in a leukemia patient in complete or partial remission or a cancer patient following reduction of the tumor burden after surgery radiotherapy and/or chemotherapy). Such a patient may be immunized to inhibit a relapse (*i.e.*, prevent or delay the relapse, or decrease the severity of a relapse). Within certain preferred embodiments, the patient is afflicted with a leukemia (*e.g.*,
20 AML, CML, ALL or childhood ALL), a myelodysplastic syndrome (MDS) or a cancer (*e.g.*, gastrointestinal, lung, thyroid or breast cancer or a melanoma), where the cancer or leukemia is WT1 positive (*i.e.*, reacts detectably with an anti-WT1 antibody, as provided herein or expresses WT1 mRNA at a level detectable by RT-PCR, as described herein) or suffers from an autoimmune
25 disease directed against WT1-expressing cells.

Other diseases associated with WT1 overexpression include kidney cancer (such as renal cell carcinoma, or Wilms tumor), as described in Satoh F., et al., *Pathol. Int.* 50(6):458-71(2000), and Campbell C. E. et al., *Int. J. Cancer* 78(2):182-8 (1998); and mesothelioma, as described in Amin, K.M. et al., *Am. J. Pathol.* 146(2):344-56 (1995). Harada et al. (*Mol. Urol.* 3(4):357-364
30 (1999) describe WT1 gene expression in human testicular germ-cell tumors.

- Nonomura et al. *Hinyokika Kyo* 45(8):593-7 (1999) describe molecular staging of testicular cancer using polymerase chain reaction of the testicular cancer-specific genes. Shimizu et al., *Int. J. Gynecol. Pathol.* 19(2):158-63 (2000) describe the immunohistochemical detection of the Wilms' tumor gene (WT1) in epithelial ovarian tumors.

- WT1 overexpression was also described in desmoplastic small round cell tumors, by Barnoud, R. et al., *Am. J. Surg. Pathol.* 24(6):830-6 (2000); and *Pathol. Res. Pract.* 194(10):693-700 (1998). WT1 overexpression in glioblastoma and other cancer was described by Menssen, H.D. et al., *J. Cancer Res. Clin. Oncol.* 126(4):226-32 (2000), "Wilms' tumor gene (WT1) expression in lung cancer, colon cancer and glioblastoma cell lines compared to freshly isolated tumor specimens." Other diseases showing WT1 overexpression include EBV associated diseases, such as Burkitt's lymphoma and nasopharyngeal cancer (Spinsanti P. et al., *Leuk. Lymphoma* 38(5-6):611-9 (2000), "Wilms' tumor gene expression by normal and malignant human B lymphocytes."

- In *Leukemia* 14(9):1634-4 (2000), Pan et al., describe *in vitro* IL-12 treatment of peripheral blood mononuclear cells from patients with leukemia or myelodysplastic syndromes, and reported an increase in cytotoxicity and reduction in WT1 gene expression. In *Leukemia* 13(6):891-900 (1999), Patmasiriwat et al. reported WT1 and GATA1 expression in myelodysplastic syndrome and acute leukemia. In *Leukemia* 13(3):393-9 (1999), Tamaki et al. reported that the Wilms' tumor gene WT1 is a good marker for diagnosis of disease progression of myelodysplastic syndromes. Expression of the Wilms' tumor gene WT1 in solid tumors, and its involvement in tumor cell growth, was discussed in relation to gastric cancer, colon cancer, lung cancer, breast cancer cell lines, germ cell tumor cell line, ovarian cancer, the uterine cancer, thyroid cancer cell line, hepatocellular carcinoma, in Oji et al., *Jpn. J. Cancer Res.* 90(2):194-204 (1999).

- The compositions provided herein may be used alone or in combination with conventional therapeutic regimens such as surgery,

- irradiation, chemotherapy and/or bone marrow transplantation (autologous, syngeneic, allogeneic or unrelated). As discussed in greater detail below, binding agents and T cells as provided herein may be used for purging of autologous stem cells. Such purging may be beneficial prior to, for example,
- 5 bone marrow transplantation or transfusion of blood or components thereof. Binding agents, T cells, antigen presenting cells (APC) and compositions provided herein may further be used for expanding and stimulating (or priming) autologous, allogeneic, syngeneic or unrelated WT1-specific T-cells *in vitro* and/or *in vivo*. Such WT1-specific T cells may be used, for example, within
- 10 donor lymphocyte infusions.

- Routes and frequency of administration, as well as dosage, will vary from individual to individual, and may be readily established using standard techniques. In general, the pharmaceutical compositions and vaccines may be administered by injection (e.g., intracutaneous, intramuscular,
- 15 intravenous or subcutaneous), intranasally (e.g., by aspiration) or orally. In some tumors, pharmaceutical compositions or vaccines may be administered locally (by, for example, rectocoloscopy, gastroscopy, videoendoscopy, angiography or other methods known in the art). Preferably, between 1 and 10 doses may be administered over a 52 week period. Preferably, 6 doses are
- 20 administered, at intervals of 1 month, and booster vaccinations may be given periodically thereafter. Alternate protocols may be appropriate for individual patients. A suitable dose is an amount of a compound that, when administered as described above, is capable of promoting an anti-tumor immune response that is at least 10-50% above the basal (*i.e.*, untreated) level. Such response
- 25 can be monitored by measuring the anti-tumor antibodies in a patient or by vaccine-dependent generation of cytolytic effector cells capable of killing the patient's tumor cells *in vitro*. Such vaccines should also be capable of causing an immune response that leads to an improved clinical outcome (e.g., more frequent complete or partial remissions, or longer disease-free and/or overall
- 30 survival) in vaccinated patients as compared to non-vaccinated patients. In general, for pharmaceutical compositions and vaccines comprising one or more

polypeptides, the amount of each polypeptide present in a dose ranges from about 100 µg to 5 mg. Suitable dose sizes will vary with the size of the patient, but will typically range from about 0.1 mL to about 5 mL.

In general, an appropriate dosage and treatment regimen

- 5 provides the active compound(s) in an amount sufficient to provide therapeutic and/or prophylactic benefit. Such a response can be monitored by establishing an improved clinical outcome (e.g., more frequent complete or partial remissions, or longer disease-free and/or overall survival) in treated patients as compared to non-treated patients. Increases in preexisting immune responses
- 10 to WT1 generally correlate with an improved clinical outcome. Such immune responses may generally be evaluated using standard proliferation, cytotoxicity or cytokine assays, which may be performed using samples obtained from a patient before and after treatment.

Within certain embodiments, immunotherapy may be active

- 15 immunotherapy, in which treatment relies on the *in vivo* stimulation of the endogenous host immune system to react against tumors with the administration of immune response-modifying agents (such as polypeptides and polynucleotides as provided herein).

Within other embodiments, immunotherapy may be passive

- 20 immunotherapy, in which treatment involves the delivery of agents with established tumor-immune reactivity (such as effector cells or antibodies) that can directly or indirectly mediate antitumor effects and does not necessarily depend on an intact host immune system. Examples of effector cells include T cells as discussed above, T lymphocytes (such as CD8⁺ cytotoxic T
- 25 lymphocytes and CD4⁺ T-helper tumor-infiltrating lymphocytes), killer cells (such as Natural Killer cells and lymphokine-activated killer cells), B cells and antigen-presenting cells (such as dendritic cells and macrophages) expressing a polypeptide provided herein. T cell receptors and antibody receptors specific for the polypeptides recited herein may be cloned, expressed and transferred
- 30 into other vectors or effector cells for adoptive immunotherapy. The polypeptides provided herein may also be used to generate antibodies or anti-

idiotypic antibodies (as described above and in U.S. Patent No. 4,918,164) for passive immunotherapy.

Monoclonal antibodies may be labeled with any of a variety of labels for desired selective usages in detection, diagnostic assays or
5 therapeutic applications (as described in U.S. Patent Nos. 6,090,365; 6,015,542; 5,843,398; 5,595,721; and 4,708,930, hereby incorporated by reference in their entirety as if each was incorporated individually). In each case, the binding of the labelled monoclonal antibody to the determinant site of the antigen will signal detection or delivery of a particular therapeutic agent to
10 the antigenic determinant on the non-normal cell. A further object of this invention is to provide the specific monoclonal antibody suitably labelled for achieving such desired selective usages thereof.

Effector cells may generally be obtained in sufficient quantities for adoptive immunotherapy by growth *in vitro*, as described herein. Culture
15 conditions for expanding single antigen-specific effector cells to several billion in number with retention of antigen recognition *in vivo* are well known in the art. Such *in vitro* culture conditions typically use intermittent stimulation with antigen, often in the presence of cytokines (such as IL-2) and non-dividing feeder cells. As noted above, immunoreactive polypeptides as provided herein
20 may be used to rapidly expand antigen-specific T cell cultures in order to generate a sufficient number of cells for immunotherapy. In particular, antigen-presenting cells, such as dendritic, macrophage, monocyte, fibroblast and/or B cells, may be pulsed with immunoreactive polypeptides or transfected with one or more polynucleotides using standard techniques well known in the art. For
25 example, antigen-presenting cells can be transfected with a polynucleotide having a promoter appropriate for increasing expression in a recombinant virus or other expression system. Cultured effector cells for use in therapy must be able to grow and distribute widely, and to survive long term *in vivo*. Studies have shown that cultured effector cells can be induced to grow *in vivo* and to
30 survive long term in substantial numbers by repeated stimulation with antigen

supplemented with IL-2 (see, for example, Cheever et al., *Immunological Reviews* 157:177, 1997).

Alternatively, a vector expressing a polypeptide recited herein may be introduced into antigen presenting cells taken from a patient and
5 clonally propagated *ex vivo* for transplant back into the same patient. Transfected cells may be reintroduced into the patient using any means known in the art, preferably in sterile form by Intravenous, Intracavitary, Intraperitoneal or intratumor administration.

Within further aspects, methods for inhibiting the development of
10 a malignant disease associated with WT1 expression involve the administration of autologous T cells that have been activated in response to a WT1 polypeptide or WT1-expressing APC, as described above. Such T cells may be CD4⁺ and/or CD8⁺, and may be proliferated as described above. The T cells may be administered to the individual in an amount effective to inhibit
15 the development of a malignant disease. Typically, about 1×10^9 to 1×10^{11} T cells/M² are administered intravenously, intracavitary or in the bed of a resected tumor. It will be evident to those skilled in the art that the number of cells and the frequency of administration will be dependent upon the response of the patient.

20 Within certain embodiments, T cells may be stimulated prior to an autologous bone marrow transplantation. Such stimulation may take place *in vivo* or *in vitro*. For *in vitro* stimulation, bone marrow and/or peripheral blood (or a fraction of bone marrow or peripheral blood) obtained from a patient may be contacted with a WT1 polypeptide, a polynucleotide encoding a WT1
25 polypeptide and/or an APC that expresses a WT1 polypeptide under conditions and for a time sufficient to permit the stimulation of T cells as described above. Bone marrow, peripheral blood stem cells and/or WT1-specific T cells may then be administered to a patient using standard techniques.

Within related embodiments, T cells of a related or unrelated
30 donor may be stimulated prior to a syngeneic or allogeneic (related or unrelated) bone marrow transplantation. Such stimulation may take place *in*

vivo or *in vitro*. For *in vitro* stimulation, bone marrow and/or peripheral blood (or a fraction of bone marrow or peripheral blood) obtained from a related or unrelated donor may be contacted with a WT1 polypeptide, WT1 polynucleotide and/or APC that expresses a WT1 polypeptide under conditions and for a time sufficient to permit the stimulation of T cells as described above. Bone marrow, peripheral blood stem cells and/or WT1-specific T cells may then be administered to a patient using standard techniques.

Within other embodiments, WT1-specific T cells as described herein may be used to remove cells expressing WT1 from autologous bone marrow, peripheral blood or a fraction of bone marrow or peripheral blood (e.g., CD34⁺ enriched peripheral blood (PB) prior to administration to a patient). Such methods may be performed by contacting bone marrow or PB with such T cells under conditions and for a time sufficient to permit the reduction of WT1 expressing cells to less than 10%, preferably less than 5% and more preferably less than 1%, of the total number of myeloid or lymphatic cells in the bone marrow or peripheral blood. The extent to which such cells have been removed may be readily determined by standard methods such as, for example, qualitative and quantitative PCR analysis, morphology, immunohistochemistry and FACS analysis. Bone marrow or PB (or a fraction thereof) may then be administered to a patient using standard techniques.

Cancer Detection and Diagnostic Compositions, Methods and Kits

In general, a cancer associated with WT1 expression may be detected in a patient based on the presence of one or more WT1 proteins and/or polynucleotides encoding such proteins in a biological sample (for example, blood, sera, sputum urine and/or tumor biopsies) obtained from the patient. In other words, such WT1 proteins may be used as markers to indicate the presence or absence of a cancer. The binding agents provided herein generally permit detection of the level of antigen that binds to the agent in the biological sample.

Polynucleotide primers and probes may be used to detect the level of mRNA encoding a WT1 protein, which is also indicative of the presence or absence of a cancer. In general, a WT1 sequence should be present at a level that is at least two-fold, preferably three-fold, and more preferably five-fold
5 or higher in tumor tissue than in normal tissue of the same type from which the tumor arose. Expression levels of WT1 in tissue types different from that in which the tumor arose are irrelevant in certain diagnostic embodiments since the presence of tumor cells can be confirmed by observation of predetermined differential expression levels, e.g., 2-fold, 5-fold, etc, in tumor tissue to
10 expression levels in normal tissue of the same type.

Other differential expression patterns can be utilized advantageously for diagnostic purposes. For example, in one aspect of the invention, overexpression of WT1 sequence in tumor tissue and normal tissue of the same type, but not in other normal tissue types, e.g. PBMCs, can be
15 exploited diagnostically. In this case, the presence of metastatic tumor cells, for example in a sample taken from the circulation or some other tissue site different from that in which the tumor arose, can be identified and/or confirmed by detecting expression of the tumor sequence in the sample, for example using RT-PCR analysis. In many instances, it will be desired to enrich for
20 tumor cells in the sample of interest, e.g., PBMCs, using cell capture or other like techniques.

There are a variety of assay formats known to those of ordinary skill in the art for using a binding agent to detect WT1 polypeptide markers in a sample. See, e.g., Harlow and Lane, *Antibodies: A Laboratory Manual*, Cold
25 Spring Harbor Laboratory, 1988. In general, the presence or absence of a cancer associated with WT1 in a patient may be determined by (a) contacting a biological sample obtained from a patient with a binding agent; (b) detecting in the sample a level of WT1 polypeptide that binds to the binding agent; and (c) comparing the level of WT1 polypeptide with a predetermined cut-off value.

30 In a preferred embodiment, the assay involves the use of binding agent immobilized on a solid support to bind to and remove the WT1

polypeptide from the remainder of the sample. The bound WT1 polypeptide may then be detected using a detection reagent that contains a reporter group and specifically binds to the binding agent/WT1 polypeptide complex. Such detection reagents may comprise, for example, a binding agent that specifically
5 binds to a WT1 polypeptide or an antibody or other agent that specifically binds to the binding agent, such as an anti-immunoglobulin, protein G, protein A or a lectin. Alternatively, a competitive assay may be utilized, in which a WT1 polypeptide is labeled with a reporter group and allowed to bind to the immobilized binding agent after incubation of the binding agent with the
10 sample. The extent to which components of the sample inhibit the binding of the labeled WT1 polypeptide to the binding agent is indicative of the reactivity of the sample with the immobilized binding agent. Suitable polypeptides for use within such assays include full length WT1 proteins and polypeptide portions thereof to which the binding agent binds, as described above.

15 The solid support may be any material known to those of ordinary skill in the art to which the WT1 protein may be attached. For example, the solid support may be a test well in a microtiter plate or a nitrocellulose or other suitable membrane. Alternatively, the support may be a bead or disc, such as glass, fiberglass, latex or a plastic material such as polystyrene or
20 polyvinylchloride. The support may also be a magnetic particle or a fiber optic sensor, such as those disclosed, for example, in U.S. Patent No. 5,359,681. The binding agent may be immobilized on the solid support using a variety of techniques known to those of skill in the art, which are amply described in the patent and scientific literature. In the context of the present invention, the term
25 "immobilization" refers to both noncovalent association, such as adsorption, and covalent attachment (which may be a direct linkage between the agent and functional groups on the support or may be a linkage by way of a cross-linking agent). Immobilization by adsorption to a well in a microtiter plate or to a membrane is preferred. In such cases, adsorption may be achieved by
30 contacting the binding agent, in a suitable buffer, with the solid support for a suitable amount of time. The contact time varies with temperature, but is

typically between about 1 hour and about 1 day. In general, contacting a well of a plastic microtiter plate (such as polystyrene or polyvinylchloride) with an amount of binding agent ranging from about 10 ng to about 10 μ g, and preferably about 100 ng to about 1 μ g, is sufficient to immobilize an adequate amount of binding agent.

Covalent attachment of binding agent to a solid support may generally be achieved by first reacting the support with a bifunctional reagent that will react with both the support and a functional group, such as a hydroxyl or amino group, on the binding agent. For example, the binding agent may be covalently attached to supports having an appropriate polymer coating using benzoquinone or by condensation of an aldehyde group on the support with an amine and an active hydrogen on the binding partner (*see, e.g.*, Pierce Immunotechnology Catalog and Handbook, 1991, at A12-A13).

In certain embodiments, the assay is a two-antibody sandwich assay. This assay may be performed by first contacting an antibody that has been immobilized on a solid support, commonly the well of a microtiter plate, with the sample, such that WT1 polypeptides within the sample are allowed to bind to the immobilized antibody. Unbound sample is then removed from the immobilized polypeptide-antibody complexes and a detection reagent (preferably a second antibody capable of binding to a different site on the polypeptide) containing a reporter group is added. The amount of detection reagent that remains bound to the solid support is then determined using a method appropriate for the specific reporter group.

More specifically, once the antibody is immobilized on the support as described above, the remaining protein binding sites on the support are typically blocked. Any suitable blocking agent known to those of ordinary skill in the art, such as bovine serum albumin or Tween 20™ (Sigma Chemical Co., St. Louis, MO). The immobilized antibody is then incubated with the sample, and polypeptide is allowed to bind to the antibody. The sample may be diluted with a suitable diluent, such as phosphate-buffered saline (PBS) prior to incubation. In general, an appropriate contact time (*i.e.*, incubation time) is a

- period of time that is sufficient to detect the presence of WT1 polypeptide within a sample obtained from an individual with a cancer associated with WT1 least about 95% of that achieved at equilibrium between bound and unbound polypeptide. Those of ordinary skill in the art will recognize that the time
- 5 necessary to achieve equilibrium may be readily determined by assaying the level of binding that occurs over a period of time. At room temperature, an incubation time of about 30 minutes is generally sufficient.

- Unbound sample may then be removed by washing the solid support with an appropriate buffer, such as PBS containing 0.1% Tween 20™.
- 10 The second antibody, which contains a reporter group, may then be added to the solid support. Preferred reporter groups include those groups recited above.

- The detection reagent is then incubated with the immobilized antibody-polypeptide complex for an amount of time sufficient to detect the bound polypeptide. An appropriate amount of time may generally be
- 15 determined by assaying the level of binding that occurs over a period of time. Unbound detection reagent is then removed and bound detection reagent is detected using the reporter group. The method employed for detecting the reporter group depends upon the nature of the reporter group. For radioactive
- 20 groups, scintillation counting or autoradiographic methods are generally appropriate. Spectroscopic methods may be used to detect dyes, luminescent groups and fluorescent groups. Biotin may be detected using avidin, coupled to a different reporter group (commonly a radioactive or fluorescent group or an enzyme). Enzyme reporter groups may generally be detected by the addition
- 25 of substrate (generally for a specific period of time), followed by spectroscopic or other analysis of the reaction products.

- To determine the presence or absence of a cancer associated with WT1 expression the signal detected from the reporter group that remains bound to the solid support is generally compared to a signal that corresponds
- 30 to a predetermined cut-off value. In one preferred embodiment, the cut-off value for the detection of a cancer associated with WT1 is the average mean

signal obtained when the immobilized antibody is incubated with samples from patients without the cancer. In general, a sample generating a signal that is three standard deviations above the predetermined cut-off value is considered positive for the cancer. In an alternate preferred embodiment, the cut-off value is determined using a Receiver Operator Curve, according to the method of Sackett et al., *Clinical Epidemiology: A Basic Science for Clinical Medicine*, Little Brown and Co., 1985, p. 106-7. Briefly, In this embodiment, the cut-off value may be determined from a plot of pairs of true positive rates (*i.e.*, sensitivity) and false positive rates (100%-specificity) that correspond to each possible cut-off value for the diagnostic test result. The cut-off value on the plot that is the closest to the upper left-hand corner (*i.e.*, the value that encloses the largest area) is the most accurate cut-off value, and a sample generating a signal that is higher than the cut-off value determined by this method may be considered positive. Alternatively, the cut-off value may be shifted to the left along the plot, to minimize the false positive rate, or to the right, to minimize the false negative rate. In general, a sample generating a signal that is higher than the cut-off value determined by this method is considered positive for a cancer.

In a related embodiment, the assay is performed in a flow-through or strip test format, wherein the binding agent is immobilized on a membrane, such as nitrocellulose. In the flow-through test, polypeptides within the sample bind to the immobilized binding agent as the sample passes through the membrane. A second, labeled binding agent then binds to the binding agent-polypeptide complex as a solution containing the second binding agent flows through the membrane. The detection of bound second binding agent may then be performed as described above. In the strip test format, one end of the membrane to which binding agent is bound is immersed in a solution containing the sample. The sample migrates along the membrane through a region containing second binding agent and to the area of immobilized binding agent. Concentration of second binding agent at the area of immobilized antibody indicates the presence of a cancer. Typically, the concentration of second binding agent at that site generates a pattern, such as a line, that can be read

visually. The absence of such a pattern indicates a negative result. In general, the amount of binding agent immobilized on the membrane is selected to generate a visually discernible pattern when the biological sample contains a level of polypeptide that would be sufficient to generate a positive signal in the

5 two-antibody sandwich assay, in the format discussed above. Preferred binding agents for use in such assays are antibodies and antigen-binding fragments thereof. Preferably, the amount of antibody immobilized on the membrane ranges from about 25 ng to about 1 μ g, and more preferably from about 50 ng to about 500 ng. Such tests can typically be performed with a very

10 small amount of biological sample.

Of course, numerous other assay protocols exist that are suitable for use with the WT1 proteins or binding agents of the present invention. The above descriptions are intended to be exemplary only. For example, it will be apparent to those of ordinary skill in the art that the above protocols may be

15 readily modified to use tumor polypeptides to detect antibodies that bind to such polypeptides in a biological sample. The detection of such WT1-specific antibodies may correlate with the presence of a cancer associated with WT1 expression.

A cancer associated with WT1 expression may also, or

20 alternatively, be detected based on the presence of T cells that specifically react with a tumor protein in a biological sample. Within certain methods, a biological sample comprising CD4⁺ and/or CD8⁺ T cells isolated from a patient is incubated with a WT1 polypeptide, a polynucleotide encoding such a polypeptide and/or an APC that expresses at least an immunogenic portion of

25 such a polypeptide, and the presence or absence of specific activation of the T cells is detected. Suitable biological samples include, but are not limited to, isolated T cells. For example, T cells may be isolated from a patient by routine techniques (such as by Ficoll/Hypaque density gradient centrifugation of peripheral blood lymphocytes). T cells may be incubated *in vitro* for 2-9 days

30 (typically 4 days) at 37°C with polypeptide (e.g., 5 - 25 μ g/ml). It may be desirable to incubate another aliquot of a T cell sample in the absence of WT1

- polypeptide to serve as a control. For CD4⁺ T cells, activation is preferably detected by evaluating proliferation of the T cells. For CD8⁺ T cells, activation is preferably detected by evaluating cytolytic activity. A level of proliferation that is at least two fold greater and/or a level of cytolytic activity that is at least
- 5 20% greater than in disease-free patients indicates the presence of a cancer associated with WT1 expression in the patient.

As noted above, a cancer may also, or alternatively, be detected based on the level of mRNA encoding a WT1 protein in a biological sample. For example, at least two oligonucleotide primers may be employed in a

10 polymerase chain reaction (PCR) based assay to amplify a portion of a WT1 cDNA derived from a biological sample, wherein at least one of the oligonucleotide primers is specific for (*i.e.*, hybridizes to) a polynucleotide encoding the WT1 protein. The amplified cDNA is then separated and detected using techniques well known in the art, such as gel electrophoresis.

- 15 Similarly, oligonucleotide probes that specifically hybridize to a polynucleotide encoding a WT1 protein may be used in a hybridization assay to detect the presence of polynucleotide encoding the WT1 protein in a biological sample.

To permit hybridization under assay conditions, oligonucleotide

20 primers and probes should comprise an oligonucleotide sequence that has at least about 60%, preferably at least about 75% and more preferably at least about 90%, identity to a portion of a polynucleotide encoding a WT1 protein of the invention that is at least 10 nucleotides, and preferably at least 20 nucleotides, in length. Preferably, oligonucleotide primers and/or probes

25 hybridize to a polynucleotide encoding a polypeptide described herein under moderately stringent conditions, as defined above. Oligonucleotide primers and/or probes which may be usefully employed in the diagnostic methods described herein preferably are at least 10-40 nucleotides in length. In a preferred embodiment, the oligonucleotide primers comprise at least 10

30 contiguous nucleotides, more preferably at least 15 contiguous nucleotides, of a DNA molecule having a sequence as disclosed herein. Techniques for both

PCR based assays and hybridization assays are well known in the art (see, for example, Mullis et al., *Cold Spring Harbor Symp. Quant. Biol.*, 51:263, 1987; Erlich ed., *PCR Technology*, Stockton Press, NY, 1989).

One preferred assay employs RT-PCR, in which PCR is applied
5 in conjunction with reverse transcription. Typically, RNA is extracted from a biological sample, such as biopsy tissue, and is reverse transcribed to produce cDNA molecules. PCR amplification using at least one specific primer generates a cDNA molecule, which may be separated and visualized using, for example, gel electrophoresis. Amplification may be performed on biological
10 samples taken from a test patient and from an individual who is not afflicted with a cancer. The amplification reaction may be performed on several dilutions of cDNA spanning two orders of magnitude. A two-fold or greater increase in expression in several dilutions of the test patient sample as compared to the same dilutions of the non-cancerous sample is typically
15 considered positive.

In another aspect of the present invention, cell capture technologies may be used in conjunction with, for example, real-time PCR to provide a more sensitive tool for detection of metastatic cells expressing WT1 antigens. Detection of WT1-associated cancer cells in biological samples, e.g.,
20 bone marrow samples, peripheral blood, and small needle aspiration samples is desirable for diagnosis and prognosis in patients with cancer associated with WT1 expression.

Immunomagnetic beads coated with specific monoclonal antibodies to surface cell markers, or tetrameric antibody complexes, may be
25 used to first enrich or positively select cancer cells in a sample. Various commercially available kits may be used, including Dynabeads® Epithelial Enrich (DynaL Biotech, Oslo, Norway), StemSep™ (StemCell Technologies, Inc., Vancouver, BC), and RosetteSep (StemCell Technologies). A skilled artisan will recognize that other methodologies and kits may also be used to
30 enrich or positively select desired cell populations. Dynabeads® Epithelial Enrich contains magnetic beads coated with mAbs specific for two glycoprotein

membrane antigens expressed on normal and neoplastic epithelial tissues. The coated beads may be added to a sample and the sample then applied to a magnet, thereby capturing the cells bound to the beads. The unwanted cells are washed away and the magnetically isolated cells eluted from the beads and
5 used in further analyses.

RosetteSep can be used to enrich cells directly from a blood sample and consists of a cocktail of tetrameric antibodies that targets a variety of unwanted cells and crosslinks them to glycophorin A on red blood cells (RBC) present in the sample, forming rosettes. When centrifuged over Ficoll,
10 targeted cells pellet along with the free RBC. The combination of antibodies in the depletion cocktail determines which cells will be removed and consequently which cells will be recovered. Antibodies that are available include, but are not limited to: CD2, CD3, CD4, CD5, CD8, CD10, CD11b, CD14, CD15, CD16, CD19, CD20, CD24, CD25, CD29, CD33, CD34, CD36, CD38, CD41, CD45,
15 CD45RA, CD45RO, CD56, CD66B, CD66e, HLA-DR, IgE, and TCR $\alpha\beta$.

In another embodiment, the compositions described herein may be used as markers for the progression of cancer. In this embodiment, assays as described above for the diagnosis of a cancer associated with WT1 expression may be performed over time, and the change in the level of reactive
20 polypeptide(s) or polynucleotide(s) evaluated. For example, the assays may be performed every 24-72 hours for a period of 6 months to 1 year, and thereafter performed as needed. In general, a cancer is progressing in those patients in whom the level of WT1 polypeptide or polynucleotide detected increases over time. In contrast, the cancer is not progressing when the level of reactive
25 polypeptide or polynucleotide either remains constant or decreases with time.

Certain *in vivo* diagnostic assays may be performed directly on a tumor. One such assay involves contacting tumor cells with a binding agent. The bound binding agent may then be detected directly or indirectly via a reporter group. Such binding agents may also be used in histological
30 applications. Alternatively, polynucleotide probes may be used within such applications.

The present invention further provides kits for use within any of the above diagnostic methods. Such kits typically comprise two or more components necessary for performing a diagnostic assay. Components may be compounds, reagents, containers and/or equipment. For example, one
5 container within a kit may contain a monoclonal antibody or fragment thereof that specifically binds to a WT1 protein. Such antibodies or fragments may be provided attached to a support material, as described above. One or more additional containers may enclose elements, such as reagents or buffers, to be used in the assay. Such kits may also, or alternatively, contain a detection
10 reagent as described above that contains a reporter group suitable for direct or indirect detection of antibody binding.

Alternatively, a kit may be designed to detect the level of mRNA encoding a WT1 protein in a biological sample. Such kits generally comprise at least one oligonucleotide probe or primer, as described above, that hybridizes
15 to a polynucleotide encoding a WT1 protein. Such an oligonucleotide may be used, for example, within a PCR or hybridization assay. Additional components that may be present within such kits include a second oligonucleotide and/or a diagnostic reagent or container to facilitate the detection of a polynucleotide encoding a WT1 protein.

20 The following Examples are offered by way of illustration and not by way of limitation.

EXAMPLES

25

EXAMPLE 1

IDENTIFICATION OF AN IMMUNE RESPONSE TO WT1 IN PATIENTS WITH HEMATOLOGICAL MALIGNANCIES

This Example illustrates the identification of an existent immune response in patients with a hematological malignancy.

30

To evaluate the presence of preexisting WT1 specific antibody responses in patients, sera of patients with acute myelogenous leukemia

(AML), acute lymphocytic leukemia (ALL), chronic myelogenous leukemia (CML) and severe aplastic anemia were analyzed using Western blot analysis. Sera were tested for the ability to immunoprecipitate WT1 from the human leukemic cell line K562 (American Type Culture Collection, Manassas, VA). In each case, immunoprecipitates were separated by gel electrophoresis, transferred to membrane and probed with the anti WT1 antibody WT180 (Santa Cruz Biotechnology, Inc., Santa Cruz, CA). This Western blot analysis identified potential WT1 specific antibodies in patients with hematological malignancy. A representative Western blot showing the results for a patient with AML is shown in Figure 2. A 52 kD protein in the immunoprecipitate generated using the patient sera was recognized by the WT1 specific antibody. The 52 kD protein migrated at the same size as the positive control.

Additional studies analyzed the sera of patients with AML and CML for the presence of antibodies to full-length and truncated WT1 proteins. CDNA constructs representing the human WT1/full-length (aa 1-449), the N-terminus (aa 1-249) (WT1/N-terminus) and C-terminus (aa 267-449) (WT1/C-terminus) region were subcloned into modified pET28 vectors. The WT1/full-length and WT1/N-terminus proteins were expressed as Ra12 fusion proteins. Ra12 is the C-terminal fragment of a secreted *Mycobacterium tuberculosis* protein, denoted as MTB32B. (Skeiky et al., *Infect Immun.* 67;3998, 1999). The Ra12-WT1/full-length fusion region was cloned 3' to a histidine-tag in a histidine-tag modified pET28 vector. The WT1/N-terminus region was subcloned into a modified pET28 vector that has a 5' histidine-tag followed by the thioredoxin (TRX)-WT1/N-terminus fusion region followed by a 3' histidine-tag. The WT1/C-terminus coding region was subcloned into a modified pET28 vector without a fusion partner containing only the 5' and 3' histidine-tag, followed by a Thrombin and EK site.

BL21 pLysS *E. coli* (Stratagene, La Jolla, CA) were transformed with the three WT1 expression constructs, grown overnight and induced with Isopropyl- β -D-thiogalactoside (IPTG). WT1 proteins were purified as follows: Cells were harvested and lysed by incubation in 10mM Tris, pH 8.0 with

- Complete Protease Inhibitor Tablets (Boehringer Mannheim Biochemicals, Indianapolis, IN) at 37°C followed by repeated rounds of sonication. Inclusion bodies were washed twice with 10mM Tris, pH 8.0. Proteins were then purified by metal chelate affinity chromatography over nickel-nitrilotriacetic acid resin
- 5 (QIAGEN Inc., Valencia, CA; Hochuli et al., *Biologically Active Molecules* :217, 1989) followed by chromatography on a Source Q anion exchange resin (Amersham Pharmacia Biotech, Upsala, Sweden). The identity of the WT1 proteins was confirmed by N-terminal sequencing.

- Sera from adult patients with *de nova* AML or CML were studied
- 10 for the presence of WT1 specific Ab. Recombinant proteins were adsorbed to TC microwell plates (Nunc, Roskilde, Denmark). Plates were washed with PBS/0.5%Tween 20 and blocked with 1% BSA/PBS/0.1%Tween 20. After washing, serum dilutions were added and incubated overnight at 4°C. Plates were washed and Donkey anti-human IgG-HRP secondary antibody was added
- 15 (Jackson-Immunochem, West Grove, PA) and incubated for 2h at room temperature. Plates were washed, incubated with TMB Peroxidase substrate solution (Kirkegaard and Perry Laboratories, MA), quenched with 1N H₂SO₄, and immediately read (Cyto-Fluor 2350; Millipore, Bedford, MA).

- For the serological survey, human sera were tested by ELISA
- 20 over a range of serial dilutions from 1:50 to 1:20,000. A positive reaction was defined as an OD value of a 1:500 diluted serum that exceeded the mean OD value of sera from normal donors (n=96) by three (WT1/full-length, WT1C-terminus) standard deviations. Due to a higher background in normal donors to the WT1/N-terminus protein a positive reaction to WT1/N-terminus was defined
- 25 as an OD value of 1:500 diluted serum that exceeded the mean OD value of sera from normal donors by four standard deviations. To verify that the patient Ab response was directed against WT1 and not to the Ra12 or TRX fusion part of the protein or possible *E. coli* contaminant proteins, controls included the Ra12 and TRX protein alone purified in a similar manner. Samples that
- 30 showed reactivity against the Ra12 and/or TRX proteins were excluded from the analysis.

To evaluate for the presence of immunity to WT1, Ab to recombinant full-length and truncated WT1 proteins in the sera of normal individuals and patients with leukemia were determined. Antibody reactivity was analyzed by ELISA reactivity to WT1/full-length protein, WT1/N-terminus protein and WT1/C-terminus protein.

Only 2 of 96 normal donors had serum antibodies reactive with WT1/full-length protein (Figure 18). One of those individuals had antibody to WT1/N-terminus protein and one had antibody to WT1/C-terminus protein. In contrast, 16 of 63 patients (25%) with AML had serum antibodies reactive with WT1/full-length protein. By marked contrast, only 2 of 63 patients (3%) had reactivity to WT1/C-terminus protein. Fifteen of 81 patients (19%) with CML had serum antibodies reactive with WT1/full-length protein and 12 of 81 patients (15%) had serum antibodies reactive with WT1/N-terminus. Only 3 of 81 patients (3%) had reactivity to WT1/C-terminus protein. (Figures 16 and 17.)

These data demonstrate that Ab responses to WT1 are detectable in some patients with AML and CML. The greater incidence of antibody in leukemia patients provides strong evidence that immunization to the WT1 protein occurred as a result of patients bearing malignancy that expresses or at some time expressed WT1. Without being limited to a specific theory, it is believed that the observed antibody responses to WT1 most probably result from patients becoming immune to WT1 on their own leukemia cells and provide direct evidence that WT1 can be immunogenic despite being a "self" protein.

The presence of antibody to WT1 strongly implies that concurrent helper T cell responses are also present in the same patients. WT1 is an internal protein. Thus, CTL responses are likely to be the most effective in terms of leukemia therapy and the most toxic arm of immunity. Thus, these data provide evidence that therapeutic vaccines directed against WT1 will be able to elicit an immune response to WT1.

The majority of the antibodies detected were reactive with epitopes within the N-terminus while only a small subgroup of patients showed a weak antibody response to the C-terminus. This is consistent with observations in the animal model, where immunization with peptides derived from the N-terminus elicited antibody, helper T cell and CTL responses, whereas none of the peptides tested from the C-terminus elicited antibody or T cell responses (Gaiger et al., *Blood* 96:1334, 2000).

EXAMPLE 2

10 INDUCTION OF ANTIBODIES TO WT1 IN MICE IMMUNIZED WITH CELL LINES EXPRESSING WT1

This Example illustrates the use of cells expressing WT1 to induce a WT1 specific antibody response *in vivo*.

Detection of existent antibodies to WT1 in patients with leukemia strongly implied that it is possible to immunize to WT1 protein to elicit immunity to WT1. To test whether immunity to WT1 can be generated by vaccination, mice were injected with TRAMP-C, a WT1 positive tumor cell line of B6 origin. Briefly, male B6 mice were immunized with 5×10^6 TRAMP-C cells subcutaneously and boosted twice with 5×10^6 cells at three week intervals. Three weeks after the final immunization, sera were obtained and single cell suspensions of spleens were prepared in RPMI 1640 medium (GIBCO) with $25\mu\text{M}$ β -2-mercaptoethanol, 200 units of penicillin per ml, 10mM L-glutamine, and 10% fetal bovine serum.

Following immunization to TRAMP-C, a WT1 specific antibody response in the immunized animals was detectable. A representative Western blot is shown in Figure 3. These results show that immunization to WT1 protein can elicit an immune response to WT1 protein.

EXAMPLE 3

INDUCTION OF TH AND ANTIBODY RESPONSES IN MICE IMMUNIZED WITH WT1

PEPTIDES

This Example illustrates the ability of immunization with WT1
 5 peptides to elicit an immune response specific for WT1.

Peptides suitable for eliciting Ab and proliferative T cell responses
 were identified according to the Tsites program (Rothbard and Taylor, *EMBO J.*
 7:93-100, 1988; Deavin et al., *Mol. Immunol.* 33:145-155, 1996), which
 searches for peptide motifs that have the potential to elicit Th responses.
 10 Peptides shown in Table I were synthesized and sequenced.

Table I
WT1 Peptides

Peptide	Sequence	Comments
Mouse: p6-22	RDLNALLPAVSSLGGGG (SEQ ID NO:13)	1 mismatch relative to human WT1 sequence
Human: p6-22	RDLNALLPAVPSLGGGG (SEQ ID NO:1)	
Human/mouse: p117-139	PSQASSGQARMFPNAPYLPSCLE (SEQ ID NOs: 2 and 3)	
Mouse: p244- 262	GATLKGMAAGSSSSVKWTE (SEQ ID NO:14)	1 mismatch relative to human WT1 sequence
Human: p244- 262	GATLKGVAAGSSSSVKWTE (SEQ ID NO:4)	
Human/mouse: p287-301	RIHTHGVRGIQDVR (SEQ ID NOs: 15 and 16)	
Mouse: p299- 313	VRRVSGVAPTLVRS (SEQ ID NO:17)	1 mismatch relative to human WT1 sequence
Human/mouse: p421-435	CQKKFARSEDLVRHH (SEQ ID NOs: 19 and 20)	

15

For immunization, peptides were grouped as follows:

- Group A: p6-22 human: 10.9mg in 1ml ($10\mu\text{l} = 100\mu\text{g}$)
 p117-139 human/mouse: 7.6mg in 1ml ($14\mu\text{l} = 100\mu\text{g}$)
 p244-262 human: 4.6.mg in 1ml ($22\mu\text{l} = 100\mu\text{g}$)
- Group B: p287-301 human/mouse: 7.2mg in 1ml ($14\mu\text{l} = 100\mu\text{g}$)
 mouse p299-313: 6.6.mg in 1ml ($15\mu\text{l} = 100\mu\text{g}$)
 p421-435 human/mouse: 3.3mg in 1ml ($30\mu\text{l} = 100\mu\text{g}$)
- Control: (FBL peptide $100\mu\text{g}$) + CFA/IFA
- Control: (CD45 peptide $100\mu\text{g}$) + CFA/IFA

Group A contained peptides present within the amino terminus portion of WT1 (exon 1) and Group B contained peptides present within the carboxy terminus, which contains a four zinc finger region with sequence homology to other DNA-binding proteins. Within group B, p287-301 and p299-313 were derived from exon 7, zinc finger 1, and p421-435 was derived from exon 10, zinc finger IV.

B6 mice were immunized with a group of WT1 peptides or with a control peptide. Peptides were dissolved in 1ml sterile water for injection, and B6 mice were immunized 3 times at time intervals of three weeks. Adjuvants used were CFA/IFA, GM-CSF, and Montanide. The presence of antibodies specific for WT1 was then determined as described in Examples 1 and 2, and proliferative T cell responses were evaluated using a standard thymidine incorporation assay, in which cells were cultured in the presence of antigen and proliferation was evaluated by measuring incorporated radioactivity (Chen et al., *Cancer Res.* 54:1065-1070, 1994). In particular, lymphocytes were cultured in 96-well plates at 2×10^5 cells per well with 4×10^5 irradiated (3000 rads) syngeneic spleen cells and the designated peptide.

Immunization of mice with the group of peptides designated as Group A elicited an antibody response to WT1 (Figure 4). No antibodies were detected following immunization to Vaccine B, which is consistent with a lack of helper T cell response from immunization with Vaccine B. P117-139 elicited

proliferative T cell responses (Figures 5A-5C). The stimulation indices (SI) varied between 8 and 72. Other peptides (P6-22 and P299-313) also were shown to elicit proliferative T cell responses. Immunization with P6-22 resulted in a stimulation index (SI) of 2.3 and immunization with P299-313 resulted in a SI of 3.3. Positive controls included ConA stimulated T cells, as well as T cells stimulated with known antigens, such as CD45 and FBL, and allogeneic T cell lines (DeBruijn et al., *Eur. J. Immunol.* 21:2963-2970, 1991).

Figures 6A and 6B show the proliferative response observed for each of the three peptides within vaccine A (Figure 6A) and vaccine B (Figure 6B). Vaccine A elicited proliferative T cell responses to the immunizing peptides p6-22 and p117-139, with stimulation indices (SI) varying between 3 and 8 (bulk lines). No proliferative response to p244-262 was detected (Figure 6A).

Subsequent *in vitro* stimulations were carried out as single peptide stimulations using only p6-22 and p117-139. Stimulation of the Vaccine A specific T cell line with p117-139 resulted in proliferation to p117-139 with no response to p6-22 (Figure 7A). Clones derived from the line were specific for p117-139 (Figure 7B). By contrast, stimulation of the Vaccine A specific T cell line with p6-22 resulted in proliferation to p6-22 with no response to p117-139 (Figure 7C). Clones derived from the line were specific for p6-22 (Figure 7D).

These results show that vaccination with WT1 peptides can elicit antibody responses to WT1 protein and proliferative T cell responses to the immunizing peptides.

25

EXAMPLE 4

INDUCTION OF CTL RESPONSES IN MICE IMMUNIZED WITH WT1 PEPTIDES

This Example illustrates the ability of WT1 peptides to elicit CTL immunity.

Peptides (9-mers) with motifs appropriate for binding to class I MHC were identified using a BIMAS HLA peptide binding prediction analysis (Parker et al., *J. Immunol.* 152:163, 1994). Peptides identified within such

30

analyses are shown in Tables II - XLIV. In each of these tables, the score reflects the theoretical binding affinity (half-time of dissociation) of the peptide to the MHC molecule indicated. Also indicated in the tables are the defined peptide binding motifs as described by Rammensee, *et al.*, Immunogenetics 41:178-228, 1995, incorporated herein in its entirety. The peptide binding motif for HLA-B14 is described in DiBrino *et al.*, J. Biol. Chem. 269:23426-23434, 1994, also incorporated herein in its entirety. Peptide positions are abbreviated as P1, P2, P3, P4, P5, P6, P7, P8, and P9.

- Peptides identified using the Tsites program (Rothbard and Taylor, *EMBO J.* 7:93-100, 1988; Deavin *et al.*, *Mol. Immunol.* 33:145-155, 1996), which searches for peptide motifs that have the potential to elicit Th responses are further shown in Figures 8A and 8B, and Table XLV.

Table II

**Results of BIMAS HLA Peptide Binding Prediction Analysis for
Binding of Human WT1 Peptides to Human HLA A1**

(HLA-A1 peptide binding motif anchor residues are D or E at position 3 (P3); Y at P9; with auxiliary anchors being P at P4 and L at P7)

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	137	CLESQPAIR (SEQ ID NO:47)	18.000
2	80	GAEPHEEQC (SEQ ID NO:87)	9.000
3	40	FAPPGASAY (SEQ ID NO:74)	5.000
4	354	QCDFKDCER (SEQ ID NO:162)	5.000
5	2	GSDVRDLNA (SEQ ID NO:101)	3.750
6	152	VTFDGTPSY (SEQ ID NO:244)	2.500
7	260	WTEGQSNHS (SEQ ID NO:247)	2.250
8	409	TSEKPFSCR (SEQ ID NO:232)	1.350
9	73	KQEPSWGGGA (SEQ ID NO:125)	1.350
10	386	KTCQRKFSSR (SEQ ID NO:128)	1.250
11	37	VLDFAAPGA (SEQ ID NO:241)	1.000
12	325	CAYPGCNKR (SEQ ID NO:44)	1.000
13	232	QLECMWTNQ (SEQ ID NO:167)	0.900
14	272	ESDNHTTPI (SEQ ID NO:71)	0.750
15	366	RSDQLKRHQ (SEQ ID NO:193)	0.750
16	222	SSDONLYQMT (SEQ ID NO:217)	0.750

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
17	427	RSDELVRHH (SEQ ID NO:191)	0.750
18	394	RSDHLKTHH (SEQ ID NO:192)	0.750
19	317	TSEKRPFMC (SEQ ID NO:233)	0.675
20	213	QALLLRTPY (SEQ ID NO:160)	0.500

Table III

Results of BIMAS HLA Peptide Binding Prediction Analysis forBinding of Human WT1 Peptides to Human HLA A 0201

(HLA-A0201 peptide binding motif anchor residues are L or M at P2; V or L at P9; with an auxiliary anchor being V at P6)

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	126	RMFPNAPYL (SEQ ID NO:185)	313.968
2	187	SLGEQQYSY (SEQ ID NO:214)	285.163
3	10	ALLPAVPSL (SEQ ID NO:34)	181.794
4	242	NLGATLKGV (SEQ ID NO:146)	159.970
5	225	NLYQMTSQL (SEQ ID NO:147)	68.360
6	292	GVFRGIQDV (SEQ ID NO:103)	51.790
7	191	QQYSVPPPV (SEQ ID NO:171)	22.566
8	280	ILCGAQYRI (SEQ ID NO:116)	17.736
9	235	CMTWNQMN (SEQ ID NO:49)	15.428
10	441	NMTKLQAL (SEQ ID NO:149)	15.428
11	7	DLNALLPAV (SEQ ID NO:58)	11.998
12	227	YQMTSQL (SEQ ID NO:251)	8.573
13	239	NQMNLGATL (SEQ ID NO:151)	8.014
14	309	TLVRSASET (SEQ ID NO:226)	7.452
15	408	KTSEKPFSC (SEQ ID NO:129)	5.743
16	340	LQMHSRKHT (SEQ ID NO:139)	4.752
17	228	QMTSOLECM (SEQ ID NO:169)	4.044
18	93	TVHFSGQFT (SEQ ID NO:235)	3.586
19	37	VLDFAAPGA (SEQ ID NO:241)	3.378
20	86	EQCLSAFTV (SEQ ID NO:69)	3.068

Table IV

Results of BIMAS HLA Peptide Binding Prediction Analysis forBinding of Human WT1 Peptides to Human HLA A 0205

- 5 (HLA-A0205 peptide binding motif anchor residues are L at P9 with auxiliary anchors being V, L, I, M at P2 and I, V, L, A, at P6)

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	10	ALLPAVPSL (SEQ ID NO:34)	42.000
2	292	GVFRGIQDV (SEQ ID NO:103)	24.000
3	126	RMFPNAPYL (SEQ ID NO:185)	21.000
4	225	NLYQMTSQL (SEQ ID NO:147)	21.000
5	239	NQMNLGATL (SEQ ID NO:151)	16.800
6	302	RVPGVAPTL (SEQ ID NO:195)	14.000
7	441	NMTKLQLAL (SEQ ID NO:149)	7.000
8	235	CMTWNQMNL (SEQ ID NO:49)	7.000
9	187	SLGEEQYSV (SEQ ID NO:214)	6.000
10	191	QQYSVPPPV (SEQ ID NO:171)	4.800
11	340	LQMHSRKHT (SEQ ID NO:139)	4.080
12	242	NLGATLKG V (SEQ ID NO:146)	4.000
13	227	YQMTSOLEC (SEQ ID NO:251)	3.600
14	194	SVPPPVYGC (SEQ ID NO:218)	2.000
15	93	TVHFSGQFT (SEQ ID NO:235)	2.000
16	280	ILCGAQYRI (SEQ ID NO:116)	1.700
17	98	GQFTGTAGA (SEQ ID NO:99)	1.200
18	309	TLVRSASET (SEQ ID NO:226)	1.000
19	81	AEPHEEQCL (SEQ ID NO:30)	0.980
20	73	KQEPSWGGA (SEQ ID NO:125)	0.960

Table V

Results of BIMAS HLA Peptide Binding Prediction Analysis forBinding of Human WT1 Peptides to Human HLA A24

- 10 (HLA-A24 peptide binding motif anchor residues are Y at P2; I, L, or F at P9; with auxiliary anchors I or V at P5 and F at P6)

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	302	RVPGVAPTL (SEQ ID NO:195)	16.800

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
2	218	RTPYSSDNL (SEQ ID NO:194)	12.000
3	356	DFKDCERRF (SEQ ID NO:55)	12.000
4	126	RMFPNAPYL (SEQ ID NO:185)	9.600
5	326	AYPGCNKRY (SEQ ID NO:42)	7.500
6	270	GYESDNHT (SEQ ID NO:106)T	7.500
7	239	NQMNLGATL (SEQ ID NO:151)	7.200
8	10	ALLPAVPSL (SEQ ID NO:34)	7.200
9	130	NAPYLPSC (SEQ ID NO:144)	7.200
10	329	GCNKRYFKL (SEQ ID NO:90)	6.600
11	417	RWPSCKKKF (SEQ ID NO:196)	6.600
12	47	AYGSLGGPA (SEQ ID NO:41)	6.000
13	180	DPMGQQGSL (SEQ ID NO:59)	6.000
14	4	DVRDLNALL (SEQ ID NO:62)	5.760
15	285	QYRIHTHGV (SEQ ID NO:175)	5.000
16	192	QYSVPPVY (SEQ ID NO:176)	5.000
17	207	DSCTGSQAL (SEQ ID NO:61)	4.800
18	441	NMTKLQAL (SEQ ID NO:149)	4.800
19	225	NLYQMTSQL (SEQ ID NO:147)	4.000
20	235	CMTWNQMNL (SEQ ID NO:49)	4.000

Table VI

Results of BIMAS HLA Peptide Binding Prediction Analysis for

Binding of Human WT1 Peptides to Human HLA A3

- 5 (HLA-A3 peptide binding motif anchor residues are L, V, or M at P2; K, Y, or F at P9; auxiliary anchors are F or Y at P3, I, M, F, V, or L at P6; I, L, M, F at P7)

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	436	NMHQRNMTK (SEQ ID NO:148)	40.000
2	240	QMNLGATLK (SEQ ID NO:168)	20.000
3	88	CLSAFTVHF (SEQ ID NO:48)	6.000
4	126	RMFPNAPYL (SEQ ID NO:185)	4.500
5	169	AQFPNHSFK (SEQ ID NO:36)	4.500
6	10	ALLPAVPSL (SEQ ID NO:34)	4.050
7	137	CLESQPAIR (SEQ ID NO:47)	4.000
8	225	NLYQMTSQL (SEQ ID NO:147)	3.000
9	32	AQWAPVLDL (SEQ ID NO:37)	2.700
10	280	ILCGAQYRI (SEQ ID NO:116)	2.700
11	386	KTCQKFSR (SEQ ID NO:128)	1.800

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
12	235	CMTWNQMNL (SEQ ID NO:49)	1.200
13	441	NMTKLQAL (SEQ ID NO:149)	1.200
14	152	VTFDGTSPY (SEQ ID NO:244)	1.000
15	187	SLGEQQYSV (SEQ ID NO:214)	0.900
16	383	FQCKTCQRK (SEQ ID NO:80)	0.600
17	292	GVFRGIQDV (SEQ ID NO:103)	0.450
18	194	SVPPPVYGC (SEQ ID NO:218)	0.405
19	287	RIHTHGVFR (SEQ ID NO:182)	0.400
20	263	GQSNHSTGY (SEQ ID NO:100)	0.360

Table VII

Results of BIMAS HLA Peptide Binding Prediction Analysis forBinding of Human WT1 Peptides to Human HLA A68.1

(HLA-A68.1 peptide binding motif anchor residues are V or T at P2; R or K at P9)

5

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	100	FTGTAGACR (SEQ ID NO:84)	100.000
2	386	KTCQRKFSR (SEQ ID NO:128)	50.000
3	368	DQLKRHQR (SEQ ID NO:60)	30.000
4	312	RSASETSEK (SEQ ID NO:190)	18.000
5	337	LSHLQMHSR (SEQ ID NO:141)	15.000
6	364	FSRSDQLKR (SEQ ID NO:83)	15.000
7	409	TSEKPFSCR (SEQ ID NO:232)	15.000
8	299	DVRRVPGVA (SEQ ID NO:63)	12.000
9	4	DVRDLNALL (SEQ ID NO:62)	12.000
10	118	SQASSGQAR (SEQ ID NO:216)	10.000
11	343	HSRKHTGEK (SEQ ID NO:111)	9.000
12	169	AQFPNHSFK (SEQ ID NO:36)	9.000
13	292	GVFRGIQDV (SEQ ID NO:103)	8.000
14	325	CAYPGCNKR (SEQ ID NO:44)	7.500
15	425	FARSDLVLR (SEQ ID NO:75)	7.500
16	354	OCDFKDCER (SEQ ID NO:162)	7.500
17	324	MCAYPGCNK (SEQ ID NO:142)	6.000
18	251	AAGSSSSVK (SEQ ID NO:28)	6.000
19	379	GVKPFQCKT (SEQ ID NO:104)	6.000
20	137	CLESQPAIR (SEQ ID NO:47)	5.000

Table VIII

Results of BIMAS HLA Peptide Binding Prediction Analysis for

Binding of Human WT1 Peptides to Human HLA A 1101

(HLA-A1101 peptide binding motif anchor residues are K at P9; auxiliary

5 anchor residues are V, I, F, Y at P2, M, L, F, Y, I, A, at P3, L, I, Y, V, or F at P7)

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	386	KTCQRKFSSR (SEQ ID NO:128)	1.800
2	169	AQFPNHSEFK (SEQ ID NO:36)	1.200
3	436	NMHQRNMTK (SEQ ID NO:148)	0.800
4	391	KFSRSDHLK (SEQ ID NO:120)	0.600
5	373	HQRRHTGVK (SEQ ID NO:109)	0.600
6	383	FQCKTCQRK (SEQ ID NO:80)	0.600
7	363	RFSRSDQLK (SEQ ID NO:178)	0.600
8	240	QMNLGATLK (SEQ ID NO:168)	0.400
9	287	RIHTHGVFR (SEQ ID NO:182)	0.240
10	100	FTGTAGACR (SEQ ID NO:84)	0.200
11	324	MCAYPGCNK (SEQ ID NO:142)	0.200
12	251	AAGSSSSVK (SEQ ID NO:28)	0.200
13	415	SCRWPSCQK (SEQ ID NO:201)	0.200
14	118	SQASSGQAR (SEQ ID NO:216)	0.120
15	292	GVFRGIQDV (SEQ ID NO:103)	0.120
16	137	CLESQPAIR (SEQ ID NO:47)	0.080
17	425	FARSDELVR (SEQ ID NO:75)	0.080
18	325	CAYPGCNKR (SEQ ID NO:44)	0.080
19	312	RSASETSEK (SEQ ID NO:190)	0.060
20	65	PPPHSFIK (SEQ ID NO:156)	0.060

Table IX

Results of BIMAS HLA Peptide Binding Prediction Analysis for

Binding of Human WT1 Peptides to Human HLA A 3101

(HLA-A3101 peptide binding motif anchor residues are R at P9; auxiliary

10 anchors L, V, Y, or F at P2; F, L, Y, W at P3, L, F, V, I, at P6)

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	386	KTCQRKFSSR (SEQ ID NO:128)	9.000
2	287	RIHTHGVFR (SEQ ID NO:182)	6.000
3	137	CLESQPAIR (SEQ ID NO:47)	2.000
4	118	SQASSGQAR (SEQ ID NO:216)	2.000

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
5	368	DQLKRHQRR (SEQ ID NO:60)	1.200
6	100	FTGTAGACR (SEQ ID NO:84)	1.000
7	293	VFRGIQDVR (SEQ ID NO:238)	0.600
8	325	CAYPGCNKR (SEQ ID NO:44)	0.600
9	169	AQFPNHSFK (SEQ ID NO:36)	0.600
10	279	PILCGAQYR (SEQ ID NO:155)	0.400
11	436	NMHQRNMTK (SEQ ID NO:148)	0.400
12	425	FARSDLVLR (SEQ ID NO:75)	0.400
13	32	AQWAPVLDL (SEQ ID NO:37)	0.240
14	240	QMNLGATLK (SEQ ID NO:168)	0.200
15	354	QCDFKDCER (SEQ ID NO:162)	0.200
16	373	HQRRHTGVK (SEQ ID NO:109)	0.200
17	383	FQCKTCQRK (SEQ ID NO:80)	0.200
18	313	SASETSEKR (SEQ ID NO:197)	0.200
19	358	KDCERRFSR (SEQ ID NO:118)	0.180
20	391	KFSRSDHLK (SEQ ID NO:120)	0.180

Table X

Results of BIMAS HLA Peptide Binding Prediction Analysis for

Binding of Human WT1 Peptides to Human HLA A 3302

(HLA-A3302 peptide binding motif anchor residues are R at P9; auxiliary anchors A, I, L, F, Y, or V at P2)

5

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	337	LSHLQMHSR (SEQ ID NO:141)	15.000
2	409	TSEKPFSCR (SEQ ID NO:232)	15.000
3	364	FSRSDQLKR (SEQ ID NO:83)	15.000
4	137	CLESQPAIR (SEQ ID NO:47)	9.000
5	368	DQLKRHQRR (SEQ ID NO:60)	9.000
6	287	RIHTHGVFR (SEQ ID NO:182)	4.500
7	210	TGSQALLLR (SEQ ID NO:223)	3.000
8	425	FARSDLVLR (SEQ ID NO:75)	3.000
9	313	SASETSEKR (SEQ ID NO:197)	3.000
10	293	VFRGIQDVR (SEQ ID NO:238)	3.000
11	354	QCDFKDCER (SEQ ID NO:162)	3.000
12	100	FTGTAGACR (SEQ ID NO:84)	3.000
13	118	SQASSGOAR (SEQ ID NO:216)	3.000
14	325	CAYPGCNKR (SEQ ID NO:44)	3.000

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
15	207	DSCTGSQAL (SEQ ID NO:61)	1.500
16	139	ESQPAIRNQ (SEQ ID NO:72)	1.500
17	299	DVRRVPGVA (SEQ ID NO:63)	1.500
18	419	PSCQKKFAR (SEQ ID NO:159)	1.500
19	272	ESDNHTTPI (SEQ ID NO:71)	1.500
20	4	DVRDLNALL (SEQ ID NO:62)	1.500

Table XI

Results of BIMAS HLA Peptide Binding Prediction Analysis for

Binding of Human WT1 Peptides to Human HLA B14

(HLA-B14 peptide binding motif anchor residues are R at P2, Y at P3, R at P5, L at P9. Three of the 4 anchor residues is sufficient)

5

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	362	RRFSRSDQL (SEQ ID NO:187)	1000.000
2	332	KRYFKLSHL (SEQ ID NO:127)	300.000
3	423	KKFARSDEL (SEQ ID NO:122)	150.000
4	390	RKFSRSDHL (SEQ ID NO:183)	150.000
5	439	QRNMTKLQL (SEQ ID NO:173)	20.000
6	329	GCKNKRYFKL (SEQ ID NO:90)	10.000
7	10	ALLPAVPSL (SEQ ID NO:34)	10.000
8	180	DPMGQQGSL (SEQ ID NO:59)	9.000
9	301	RRVPGVAPT (SEQ ID NO:189)	6.000
10	126	RMFPNAPYL (SEQ ID NO:185)	5.000
11	371	KRQRRHTG (SEQ ID NO:126)	5.000
12	225	NLYQMTSQL (SEQ ID NO:147)	5.000
13	144	IRNQGYSTV (SEQ ID NO:117)	4.000
14	429	DELVRHHNM (SEQ ID NO:53)	3.000
15	437	MHQNRMTKL (SEQ ID NO:143)	3.000
16	125	ARMFPNAPY (SEQ ID NO:38)	3.000
17	239	NQMNLGATL (SEQ ID NO:151)	3.000
18	286	YRIHTGVF (SEQ ID NO:252)	3.000
19	174	HSFKHEDPM (SEQ ID NO:110)	3.000
20	372	RHQRRHTGV (SEQ ID NO:181)	3.000

Table XII

Results of BIMAS HLA Peptide Binding Prediction Analysis forBinding of Human WT1 Peptides to Human HLA B40

(HLA-B40 peptide binding motif anchor residues are E at P2, L, W, M, or A at P9; auxiliary anchors are F, I, or V at P3)

5

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	81	AEPHEEQCL (SEQ ID NO:30)	40.000
2	429	DELVRHHNM (SEQ ID NO:53)	24.000
3	410	SEKPFSCRW (SEQ ID NO:207)	20.000
4	318	SEKRPFMCA (SEQ ID NO:208)	15.000
5	233	LECMTWNQM (SEQ ID NO:131)	12.000
6	3	SDVRDLNAL (SEQ ID NO:206)	10.000
7	349	GEKPYQCDF (SEQ ID NO:91)	8.000
8	6	RDLNALLPA (SEQ ID NO:177)	5.000
9	85	EEQCLSAFT (SEQ ID NO:65)	4.000
10	315	SETSEKRPF (SEQ ID NO:209)	4.000
11	261	TEGQSNHST (SEQ ID NO:221)	4.000
12	23	GCALPVSGA (SEQ ID NO:89)	3.000
13	38	LDFAAPPAS (SEQ ID NO:130)	3.000
14	273	SDNHTTPII (SEQ ID NO:204)	2.500
15	206	TDSCGTGSA (SEQ ID NO:220)	2.500
16	24	CALPVSGAA (SEQ ID NO:43)	2.000
17	98	GQFTGTAGA (SEQ ID NO:99)	2.000
18	30	GAAQWAPVL (SEQ ID NO:86)	2.000
19	84	HEEQCLSAF (SEQ ID NO:107)	2.000
20	26	LPVSGAAQW (SEQ ID NO:138)	2.000

Table XIII

Results of BIMAS HLA Peptide Binding Prediction Analysis forBinding of Human WT1 Peptides to Human HLA B60

(HLA-B60 peptide binding motif anchor residues are E at P2, L at P9; auxiliary anchors are I or V at P7)

10

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	81	AEPHEEQCL (SEQ ID NO:30)	160.000
2	3	SDVRDLNAL (SEQ ID NO:206)	40.000
3	429	DELVRHHNM (SEQ ID NO:53)	40.000
4	233	LECMTWNQM (SEQ ID NO:131)	22.000

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
5	273	SDNHTTPIIL (SEQ ID NO:204)	20.000
6	209	CTGSQALLL (SEQ ID NO:52)	8.000
7	30	GAAQWAPVL (SEQ ID NO:86)	8.000
8	318	SEKRPFMCA (SEQ ID NO:208)	8.000
9	180	DPMGQQGSL (SEQ ID NO:59)	8.000
10	138	LESQPAIRN (SEQ ID NO:132)	5.280
11	239	NQMNLGATL (SEQ ID NO:151)	4.400
12	329	GCNKRYFKL (SEQ ID NO:90)	4.400
13	130	NAPYLPSC (SEQ ID NO:144)	4.400
14	85	EEQCLSAFT (SEQ ID NO:65)	4.400
15	208	SCTGSQALL (SEQ ID NO:202)	4.000
16	207	DSCTGSQAL (SEQ ID NO:61)	4.000
17	218	RTPYSSDNL (SEQ ID NO:194)	4.000
18	261	TEGQSNHST (SEQ ID NO:221)	4.000
19	18	LGGGGGCGAL (SEQ ID NO:134)	4.000
20	221	YSSDNLQYM (SEQ ID NO:253)	2.200

Table XIV

Results of BIMAS HLA Peptide Binding Prediction Analysis for

Binding of Human WT1 Peptides to Human HLA B61

(HLA-B61 peptide binding motif anchor residues are E at P2, V at P9; auxiliary anchors are F, I, L, V, Y, W at P3, I at P6)

5

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	318	SEKRPFMCA (SEQ ID NO:208)	20.000
2	429	DELVRHHNM (SEQ ID NO:53)	16.000
3	298	QDVRVRPGV (SEQ ID NO:164)	10.000
4	81	AEPHEEQCL (SEQ ID NO:30)	8.000
5	233	LECMTWNQM (SEQ ID NO:131)	8.000
6	6	RDLNALLPA (SEQ ID NO:177)	5.500
7	85	EEQCLSAFT (SEQ ID NO:65)	4.000
8	261	TEGQSNHST (SEQ ID NO:221)	4.000
9	206	TDCTGSQA (SEQ ID NO:220)	2.500
10	295	RGIQDVRVR (SEQ ID NO:179)	2.200
11	3	SDVRDLNAL (SEQ ID NO:206)	2.000
12	250	VAAGSSSSV (SEQ ID NO:236)	2.000
13	29	SGAAQWAPV (SEQ ID NO:211)	2.000
14	315	SETSEKRPF (SEQ ID NO:209)	1.600

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
15	138	LESQPAIRN (SEQ ID NO:132)	1.200
16	244	GATLKGVA (SEQ ID NO:88)	1.100
17	20	GGGGCQALPV (SEQ ID NO:92)	1.100
18	440	RNMATLQLA (SEQ ID NO:186)	1.100
19	23	GCALPVSGA (SEQ ID NO:89)	1.100
20	191	QQYSVPPPV (SEQ ID NO:171)	1.000

Table XV

Results of BIMAS HLA Peptide Binding Prediction Analysis for

Binding of Human WT1 Peptides to Human HLA B62

(HLA-B62 peptide binding motif anchor residues are Q or L at P2, F or Y at P9; auxiliary anchors are I or V at P5)

5

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	146	NQGYSTVTF (SEQ ID NO:150)	211.200
2	32	AQWAPVLDF (SEQ ID NO:37)	96.000
3	263	GQSNHSTGY (SEQ ID NO:100)	96.000
4	88	CLSAFTVHF (SEQ ID NO:48)	96.000
5	17	SLGGGGGCA (SEQ ID NO:215)	9.600
6	239	NQMNLGATL (SEQ ID NO:151)	8.800
7	191	QQYSVPPPV (SEQ ID NO:171)	8.000
8	98	GQFTGTAGA (SEQ ID NO:99)	8.000
9	384	QCKTCQRKF (SEQ ID NO:163)	6.000
10	40	FAPPASAY (SEQ ID NO:74)	4.800
11	227	YQMTSQLEC (SEQ ID NO:251)	4.800
12	187	SLGEQQYSV (SEQ ID NO:214)	4.400
13	86	EQCLSAFTV (SEQ ID NO:69)	4.400
14	152	VTFDGTSPY (SEQ ID NO:244)	4.400
15	101	TGTAGACRY (SEQ ID NO:224)	4.000
16	242	NLGATLKGV (SEQ ID NO:146)	4.000
17	92	FTVHFSGQF (SEQ ID NO:85)	4.000
18	7	DLNALLPAV (SEQ ID NO:58)	4.000
19	123	GOARMFPNA (SEQ ID NO:98)	4.000
20	280	ILCGAQYRI (SEQ ID NO:116)	3.120

Table XVI

Results of BIMAS HLA Peptide Binding Prediction Analysis forBinding of Human WT1 Peptides to Human HLA B7

(HLA-B7 peptide binding motif anchor residues are P at P2, L or F at P9;
auxiliary anchor is R at P2)

5

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	180	DPMGQQGSL (SEQ ID NO:59)	240.000
2	4	DVRDLNALL (SEQ ID NO:62)	200.000
3	302	RVPGVAPTL (SEQ ID NO:195)	20.000
4	30	GAAQWAPVL (SEQ ID NO:86)	12.000
5	239	NQMNLGATL (SEQ ID NO:151)	12.000
6	130	NAPYLPSCSL (SEQ ID NO:144)	12.000
7	10	ALLPAVPSL (SEQ ID NO:34)	12.000
8	299	DVRRVPGVA (SEQ ID NO:63)	5.000
9	208	SCTGSQALL (SEQ ID NO:202)	4.000
10	303	VPGVAPTLV (SEQ ID NO:242)	4.000
11	18	LGGGGGICAL (SEQ ID NO:134)	4.000
12	218	RTPYSSDNL (SEQ ID NO:194)	4.000
13	207	DSCTGSQAL (SEQ ID NO:61)	4.000
14	209	CTGSQALLL (SEQ ID NO:52)	4.000
15	329	GCNKRYFKL (SEQ ID NO:90)	4.000
16	235	CMTWNQMNL (SEQ ID NO:49)	4.000
17	441	NMTKLQAL (SEQ ID NO:149)	4.000
18	126	RMFPNAPYL (SEQ ID NO:185)	4.000
19	225	NLYQMTSQL (SEQ ID NO:147)	4.000
20	143	AIRNQGYSY (SEQ ID NO:33)	3.000

Table XVII

Results of BIMAS HLA Peptide Binding Prediction Analysis forBinding of Human WT1 Peptides to Human HLA B8

(HLA-B8 peptide binding motif anchor residues are K at P3, K or R at P5, L at P9)

10

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	329	GCNKRYFKL (SEQ ID NO:90)	16.000
2	4	DVRDLNALL (SEQ ID NO:62)	12.000
3	316	ETSEKRPFM (SEQ ID NO:73)	3.000
4	180	DPMGQQGSL (SEQ ID NO:59)	1.600

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
5	208	SCTGSQALL (SEQ ID NO:202)	0.800
6	130	NAPYLPSCS (SEQ ID NO:144)	0.800
7	244	GATLKGVA (SEQ ID NO:88)	0.800
8	30	GAAQWAPVL (SEQ ID NO:86)	0.800
9	299	DVRRVPGVA (SEQ ID NO:63)	0.400
10	420	SCQKKFARS (SEQ ID NO:200)	0.400
11	387	TCQRKFSRS (SEQ ID NO:219)	0.400
12	225	NLYQMTSQL (SEQ ID NO:147)	0.400
13	141	QPAIRNQQY (SEQ ID NO:170)	0.400
14	10	ALLPAVPSL (SEQ ID NO:34)	0.400
15	207	DSCTGSQAL (SEQ ID NO:61)	0.400
16	384	QCKTCQRKF (SEQ ID NO:163)	0.400
17	136	SCLESQPAI (SEQ ID NO:198)	0.300
18	347	HTGEKPYQC (SEQ ID NO:112)	0.300
19	401	HTRTHTGKT (SEQ ID NO:114)	0.200
20	332	KRYFKLSHL (SEQ ID NO:127)	0.200

Table XVII

Results of BIMAS HLA Peptide Binding Prediction Analysis for

Binding of Human WT1 Peptides to Human HLA B 2702

(HLA-B2702 peptide binding motif anchor residues are R at P2; F, Y, I, L, or W at P9)

5

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	332	KRYFKLSHL (SEQ ID NO:127)	900.000
2	362	RRFSRSQDL (SEQ ID NO:187)	900.000
3	286	YRIHTGVF (SEQ ID NO:252)	200.000
4	125	ARMFPNAPY (SEQ ID NO:38)	200.000
5	375	RRHTGVKPF (SEQ ID NO:188)	180.000
6	32	AQWAPVLDL (SEQ ID NO:37)	100.000
7	301	RRVPGVAPT (SEQ ID NO:189)	60.000
8	439	QRNMTKLQL (SEQ ID NO:173)	60.000
9	126	RMFPNAPYL (SEQ ID NO:185)	22.500
10	426	ARSDLVHRH (SEQ ID NO:39)	20.000
11	146	NQGYSTVTF (SEQ ID NO:150)	20.000
12	144	IRNQGYSTV (SEQ ID NO:117)	20.000
13	389	QRKFSRSDH (SEQ ID NO:172)	20.000
14	263	GQSNHSTGY (SEQ ID NO:100)	20.000

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
15	416	CRWPSCQKK (SEQ ID NO:50)	20.000
16	191	QQYSVPPPV (SEQ ID NO:171)	10.000
17	217	LRTPYSSDN (SEQ ID NO:140)	10.000
18	107	CRYGPGFPP (SEQ ID NO:51)	10.000
19	98	GQFTGTAGA (SEQ ID NO:99)	10.000
20	239	NQMNLGATL (SEQ ID NO:151)	6.000

Table XIX

Results of BIMAS HLA Peptide Binding Prediction Analysis for

Binding of Human WT1 Peptides to Human HLA B 2705

(HLA-B2705 peptide binding motif anchor residues are R at P2; L or F at P9; Y, R, H, and K, have also been found at P9 for naturally processed epitopes)

5

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	332	KRYFKLSHL (SEQ ID NO:127)	30000.000
2	362	RRFSRSDQL (SEQ ID NO:187)	30000.000
3	416	CRWPSCQKK (SEQ ID NO:50)	10000.000
4	439	QRNMTKLQL (SEQ ID NO:173)	2000.000
5	286	YRIHTGVF (SEQ ID NO:252)	1000.000
6	125	ARMFPNAPY (SEQ ID NO:38)	1000.000
7	294	FRGIQDVRR (SEQ ID NO:81)	1000.000
8	432	VRHHNMHQR (SEQ ID NO:243)	1000.000
9	169	AQFPNHSFK (SEQ ID NO:36)	1000.000
10	375	RRHTGVKPF (SEQ ID NO:188)	900.000
11	126	RMFPNAPYL (SEQ ID NO:185)	750.000
12	144	IRNQGYSYV (SEQ ID NO:117)	600.000
13	301	RRVPGVAPT (SEQ ID NO:189)	600.000
14	32	AQWAPVLDL (SEQ ID NO:37)	500.000
15	191	QQYSVPPPV (SEQ ID NO:171)	300.000
16	373	HQRRHTGVK (SEQ ID NO:109)	200.000
17	426	ARSDLVLRH (SEQ ID NO:39)	200.000
18	383	FQCKTCQRK (SEQ ID NO:80)	200.000
19	239	NQMNLGATL (SEQ ID NO:151)	200.000
20	389	QRKFSRSDH (SEQ ID NO:172)	200.000

Table XX

Results of BIMAS HLA Peptide Binding Prediction Analysis forBinding of Human WT1 Peptides to Human HLA B 3501

(HLA-B3501 peptide binding motif anchor residues are P at P2; Y, F, M, L, or I at P9)

5

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	278	TPILCGAQY (SEQ ID NO:227)	40.000
2	141	QPAIRNQGY (SEQ ID NO:170)	40.000
3	219	TPYSSDNLY (SEQ ID NO:231)	40.000
4	327	YPGCNKRYF (SEQ ID NO:250)	20.000
5	163	TPSHHAAQF (SEQ ID NO:228)	20.000
6	180	DPMGQQGSL (SEQ ID NO:59)	20.000
7	221	YSSDNLYQM (SEQ ID NO:253)	20.000
8	26	LPVSGAAQW (SEQ ID NO:138)	10.000
9	174	HSFKHEDPM (SEQ ID NO:110)	10.000
10	82	EPHEEQCLS (SEQ ID NO:68)	6.000
11	213	QALLLRTPY (SEQ ID NO:160)	6.000
12	119	QASSGQARM (SEQ ID NO:161)	6.000
13	4	DVRDLNALL (SEQ ID NO:62)	6.000
14	40	FAPPGASAY (SEQ ID NO:74)	6.000
15	120	ASSGQARMF (SEQ ID NO:40)	5.000
16	207	DSCTGSQAL (SEQ ID NO:61)	5.000
17	303	VPGVAPTLV (SEQ ID NO:242)	4.000
18	316	ETSEKRPFM (SEQ ID NO:73)	4.000
19	152	VTFDGTPSY (SEQ ID NO:244)	4.000
20	412	KPFSCRWPS (SEQ ID NO:123)	4.000

Table XXI

Results of BIMAS HLA Peptide Binding Prediction Analysis forBinding of Human WT1 Peptides to Human HLA B 3701

(HLA-B3701 peptide binding motif anchor residues are F, M, or L at P8; I or L at P9; auxiliary anchors are D, E at P2 and V, I at P5)

10

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	3	SDVRDLNAL (SEQ ID NO:206)	40.000
2	273	SDNHTTPIL (SEQ ID NO:204)	40.000
3	81	AEPHEEQCL (SEQ ID NO:30)	10.000
4	298	QDVRRVPGV (SEQ ID NO:164)	8.000

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
5	428	SDELVRHHN (SEQ ID NO:203)	6.000
6	85	EEQCLSAFT (SEQ ID NO:65)	5.000
7	208	SCTGSQL (SEQ ID NO:202)	5.000
8	4	DVRDLNALL (SEQ ID NO:62)	5.000
9	209	CTGSQLLL (SEQ ID NO:52)	5.000
10	38	LDFAPPGAS (SEQ ID NO:130)	4.000
11	223	SDNLYQMTS (SEQ ID NO:205)	4.000
12	179	EDPMGQGS (SEQ ID NO:64)	4.000
13	206	TDSCGSQL (SEQ ID NO:220)	4.000
14	6	RDLNALLPA (SEQ ID NO:177)	4.000
15	84	HEEQCLSAF (SEQ ID NO:107)	2.000
16	233	LECMTWNQM (SEQ ID NO:131)	2.000
17	429	DELVRHHNM (SEQ ID NO:53)	2.000
18	315	SETSEKRPF (SEQ ID NO:209)	2.000
19	349	GEKPYQCDF (SEQ ID NO:91)	2.000
20	302	RVPGVAPTL (SEQ ID NO:195)	1.500

Table XXII

Results of BIMAS HLA Peptide Binding Prediction Analysis forBinding of Human WT1 Peptides to Human HLA B 3801

(HLA-B3801 peptide binding motif anchor residues are F or L at P9; Auxiliary anchors are H at P2 and D or E at P3)

5

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	437	MHQRNMTKL (SEQ ID NO:143)	36.000
2	434	HHNMHQRNM (SEQ ID NO:108)	6.000
3	372	RHQRRTHTGV (SEQ ID NO:181)	6.000
4	180	DPMGQGS (SEQ ID NO:59)	4.000
5	433	RHHNMHQRN (SEQ ID NO:180)	3.900
6	165	SHHAAQFPN (SEQ ID NO:213)	3.900
7	202	CHTPDSC (SEQ ID NO:45)	3.000
8	396	DHLKTHTRT (SEQ ID NO:57)	3.000
9	161	GHTPSHHAA (SEQ ID NO:94)	3.000
10	302	RVPGVAPTL (SEQ ID NO:195)	2.600
11	417	RWPSCQKKF (SEQ ID NO:196)	2.400
12	327	YPGCNKRYF (SEQ ID NO:250)	2.400
13	208	SCTGSQL (SEQ ID NO:202)	2.000
14	163	TPSHHAAQF (SEQ ID NO:228)	2.000

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
15	120	ASSGQARMF (SEQ ID NO:40)	2.000
16	18	LGGGGGCAL (SEQ ID NO:134)	2.000
17	177	KHEDPMGQQ (SEQ ID NO:121)	1.800
18	83	PHEEQCLSA (SEQ ID NO:154)	1.800
19	10	ALLPAVPSL (SEQ ID NO:34)	1.300
20	225	NLYQMTSQL (SEQ ID NO:147)	1.300

Table XXIII

Results of BIMAS HLA Peptide Binding Prediction Analysis for

Binding of Human WT1 Peptides to Human HLA B 3901

(HLA-B3901 peptide binding motif anchor residues are R or H at P2; L at P9; auxiliary anchors are I, V, or L at P6)

5

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	437	MHQRNMTKL (SEQ ID NO:143)	135.000
2	332	KRYFKLSHL (SEQ ID NO:127)	45.000
3	434	HHNMHQARNM (SEQ ID NO:108)	30.000
4	362	RRFSRSDQL (SEQ ID NO:187)	30.000
5	372	RHQRRHTGV (SEQ ID NO:181)	30.000
6	10	ALLPAVPSL (SEQ ID NO:34)	9.000
7	439	QRNMTKLQL (SEQ ID NO:173)	7.500
8	390	RKFSRSDHL (SEQ ID NO:183)	6.000
9	396	DHLKTHTRT (SEQ ID NO:57)	6.000
10	239	NQMLGATL (SEQ ID NO:151)	6.000
11	423	KKFARSDQL (SEQ ID NO:122)	6.000
12	126	RMFPNAPYL (SEQ ID NO:185)	6.000
13	225	NLYQMTSQL (SEQ ID NO:147)	6.000
14	180	DPMGQQGSL (SEQ ID NO:59)	6.000
15	144	IRNQQYSTV (SEQ ID NO:117)	5.000
16	136	SCLESQPAI (SEQ ID NO:198)	4.000
17	292	GVFRGIQDV (SEQ ID NO:103)	3.000
18	302	RVPGVAPTL (SEQ ID NO:195)	3.000
19	208	SCTGSQALL (SEQ ID NO:202)	3.000
20	207	DSCTGSQAL (SEQ ID NO:61)	3.000

Table XXIV

Results of BIMAS HLA Peptide Binding Prediction Analysis forBinding of Human WT1 Peptides to Human HLA B 3902

(HLA-B3902 peptide binding motif anchor residues are K or Q at P2; L at P9;
auxiliary anchors are I, L, F, or V at P5)

5

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	239	NQMNLGATL (SEQ ID NO:151)	24.000
2	390	RKFSRSDHL (SEQ ID NO:183)	20.000
3	423	KKFARSDEL (SEQ ID NO:122)	20.000
4	32	AQWAPVLDF (SEQ ID NO:37)	5.000
5	146	NOGYSTVTF (SEQ ID NO:150)	5.000
6	130	NAPYLPSC (SEQ ID NO:144)	2.400
7	225	NLYQMTSQL (SEQ ID NO:147)	2.400
8	30	GAQWAPVL (SEQ ID NO:86)	2.400
9	441	NMTKLQAL (SEQ ID NO:149)	2.400
10	302	RVPGVAPTL (SEQ ID NO:195)	2.400
11	126	RMFPNAPYL (SEQ ID NO:185)	2.000
12	218	RTPYSSDNL (SEQ ID NO:194)	2.000
13	209	CTGSQALL (SEQ ID NO:52)	2.000
14	332	KRYFKLSHL (SEQ ID NO:127)	2.000
15	180	DPMGQQGSL (SEQ ID NO:59)	2.000
16	437	MHQRNMTKL (SEQ ID NO:143)	2.000
17	207	DSCTGSQAL (SEQ ID NO:61)	2.000
18	208	SCTGSQALL (SEQ ID NO:202)	2.000
19	329	GCNKRYFKL (SEQ ID NO:90)	2.000
20	10	ALLPAVPSL (SEQ ID NO:34)	2.000

Table XXV

Results of BIMAS HLA Peptide Binding Prediction Analysis forBinding of Human WT1 Peptides to Human HLA B 4403

(HLA-B4403 peptide binding motif anchor residues are E at P2; Y or F at P9)

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	315	SETSEKRPF (SEQ ID NO:209)	80.000
2	349	GEKPYQCDF (SEQ ID NO:91)	80.000
3	84	HEEQCLSAF (SEQ ID NO:107)	60.000
4	410	SEKPFSCRW (SEQ ID NO:207)	48.000
5	429	DELVRHHNM (SEQ ID NO:53)	24.000

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
6	278	TPILCGAQY (SEQ ID NO:227)	15.000
7	141	QPAIRNOGY (SEQ ID NO:170)	9.000
8	40	FAPPGASAY (SEQ ID NO:74)	9.000
9	213	QALLLRTPY (SEQ ID NO:160)	9.000
10	318	SEKRPFMCA (SEQ ID NO:208)	8.000
11	81	AEPHEEQCL (SEQ ID NO:30)	8.000
12	152	VTFDGTSPY (SEQ ID NO:244)	4.500
13	101	TGTAGACRY (SEQ ID NO:224)	4.500
14	120	ASSGQARMF (SEQ ID NO:40)	4.500
15	261	TEGGSNHST (SEQ ID NO:221)	4.000
16	85	EEQCLSAFT (SEQ ID NO:65)	4.000
17	233	LECMTWNQM (SEQ ID NO:131)	4.000
18	104	AGACRYGPF (SEQ ID NO:31)	4.000
19	3	SDVRDLNAL (SEQ ID NO:206)	3.000
20	185	QGSLEQQY (SEQ ID NO:166)	3.000

Table XXVI

Results of BIMAS HLA Peptide Binding Prediction Analysis forBinding of Human WT1 Peptides to Human HLA B 5101

(HLA-B5101 peptide binding motif anchor residues are A, P, or G at P2; F or I at P9)

5

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	303	VPGVAPTLV (SEQ ID NO:242)	314.600
2	180	DPMGQQGSL (SEQ ID NO:59)	242.000
3	250	VAAGSSSSV (SEQ ID NO:236)	157.300
4	130	NAPYLPSC (SEQ ID NO:144)	50.000
5	30	GAAQWAPVL (SEQ ID NO:86)	50.000
6	20	GGGGCALPV (SEQ ID NO:92)	44.000
7	64	PPPPHFSI (SEQ ID NO:157)	40.000
8	29	SGAAQWAPV (SEQ ID NO:211)	40.000
9	18	LGGGGGAL (SEQ ID NO:134)	31.460
10	295	RGIODVRRV (SEQ ID NO:179)	22.000
11	119	QASSGQARM (SEQ ID NO:161)	18.150
12	418	WPSCQKKFA (SEQ ID NO:246)	12.100
13	82	EPHEEQCLS (SEQ ID NO:68)	12.100
14	110	GPFGPPPPS (SEQ ID NO:96)	11.000
15	272	ESDNHTPI (SEQ ID NO:71)	8.000

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
16	306	VAPTLVRSA (SEQ ID NO:237)	7.150
17	280	ILCGAQYRI (SEQ ID NO:116)	6.921
18	219	TPYSSDNLY (SEQ ID NO:231)	6.600
19	128	FPNAPYLPS (SEQ ID NO:79)	6.500
20	204	TPTDSC TGS (SEQ ID NO:230)	6.050

Table XXVII

Results of BIMAS HLA Peptide Binding Prediction Analysis forBinding of Human WT1 Peptides to Human HLA B 5102

(HLA-B5102 peptide binding motif anchor residues are P, A, or G at P2; I or V at P9; auxiliary anchor is Y at P3)

5

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	295	RGIQDVRRV (SEQ ID NO:179)	290.400
2	303	VPGVAPTLV (SEQ ID NO:242)	200.000
3	180	DPMGQQGSL (SEQ ID NO:59)	133.100
4	250	VAAGSSSSV (SEQ ID NO:236)	110.000
5	30	GAAQWAPVL (SEQ ID NO:86)	55.000
6	130	NAPYLP SCL (SEQ ID NO:144)	50.000
7	20	GGGGC ALPV (SEQ ID NO:92)	44.000
8	29	SGAAQWAPV (SEQ ID NO:211)	44.000
9	64	PPPPPHSFI (SEQ ID NO:157)	40.000
10	119	QASSGQARM (SEQ ID NO:161)	36.300
11	110	GPFGPPPPS (SEQ ID NO:96)	27.500
12	412	KPFSCRWPS (SEQ ID NO:123)	25.000
13	18	LGGGGGCAL (SEQ ID NO:134)	24.200
14	24	CALPVSGAA (SEQ ID NO:43)	16.500
15	219	TPYSSDNLY (SEQ ID NO:231)	15.000
16	292	GVFRGIQDV (SEQ ID NO:103)	14.641
17	136	SCLESQPAI (SEQ ID NO:198)	14.520
18	418	WPSCQKKFA (SEQ ID NO:246)	12.100
19	269	TGYESDNHT (SEQ ID NO:225)	11.000
20	351	KPYQCDFKD (SEQ ID NO:124)	11.000

Table XXVIII

Results of BIMAS HLA Peptide Binding Prediction Analysis for

Binding of Human WT1 Peptides to Human HLA B 5201

(HLA-B5201 peptide binding motif anchor residues are I or V at P8; I or V at P9; auxiliary anchors are Q at P2, F, Y, or W at P3, L, I, or V at P5)

5

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	191	QQYSVPPPV (SEQ ID NO:171)	100.000
2	32	AQWAPVLDF (SEQ ID NO:37)	30.000
3	243	LGATLKGVA (SEQ ID NO:133)	16.500
4	303	VPGVAPTLV (SEQ ID NO:242)	13.500
5	86	EQCLSAFTV (SEQ ID NO:69)	12.000
6	295	RGIQDVRRV (SEQ ID NO:179)	10.000
7	98	GQFTGTAGA (SEQ ID NO:99)	8.250
8	292	GVFRGIQDV (SEQ ID NO:103)	8.250
9	29	SGAAQWAPV (SEQ ID NO:211)	6.000
10	146	NQGYSTVTF (SEQ ID NO:150)	5.500
11	20	GGGGCALPV (SEQ ID NO:92)	5.000
12	239	NQMNLGATL (SEQ ID NO:151)	4.000
13	64	PPPPPHSFI (SEQ ID NO:157)	3.600
14	273	SDNHTTPII (SEQ ID NO:204)	3.300
15	286	YRIHTHGVF (SEQ ID NO:252)	3.000
16	269	TGYESDNHT (SEQ ID NO:225)	3.000
17	406	TGKTSEKPF (SEQ ID NO:222)	2.750
18	327	YPGCNKRYF (SEQ ID NO:250)	2.750
19	7	DLNALLPAV (SEQ ID NO:58)	2.640
20	104	AGACRYGPF (SEQ ID NO:31)	2.500

Table XXIX

Results of BIMAS HLA Peptide Binding Prediction Analysis for

Binding of Human WT1 Peptides to Human HLA B 5801

(HLA-B5801 peptide binding motif anchor residues are A, S, or T at P2; F or W at P9; auxiliary anchors are P, E, or K at P4, V, I, L, M, of F, at P5)

10

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	230	TSQLECMTW (SEQ ID NO:234)	96.800
2	92	FTVHFSGQF (SEQ ID NO:85)	60.000
3	120	ASSGQARMF (SEQ ID NO:40)	40.000
4	168	AAQFPNHSF (SEQ ID NO:29)	20.000

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
5	408	KTSEKPFSC (SEQ ID NO:129)	12.000
6	394	RSDHLKTHT (SEQ ID NO:192)	9.900
7	276	HTTPILCGA (SEQ ID NO:115)	7.200
8	218	RTPYSSDNL (SEQ ID NO:194)	6.600
9	152	VTFDGTSPY (SEQ ID NO:244)	6.000
10	40	FAPPGASAY (SEQ ID NO:74)	6.000
11	213	QALLRTPY (SEQ ID NO:160)	4.500
12	347	HTGEKPYQC (SEQ ID NO:112)	4.400
13	252	AGSSSSVKW (SEQ ID NO:32)	4.400
14	211	GSQALLRT (SEQ ID NO:102)	4.356
15	174	HSFKHEDPM (SEQ ID NO:110)	4.000
16	317	TSEKRPFMC (SEQ ID NO:233)	4.000
17	26	LPVSGAAQW (SEQ ID NO:138)	4.000
18	289	HTHGVRFGI (SEQ ID NO:113)	3.600
19	222	SSDNLQMT (SEQ ID NO:217)	3.300
20	96	FSGQFTGTA (SEQ ID NO:82)	3.300

Table XXX

Results of BIMAS HLA Peptide Binding Prediction Analysis for

Binding of Human WT1 Peptides to Human HLA CW0301

(HLA-CW0301 peptide binding motif anchor residues are L, F, M, or I at P9; auxiliary anchors are V, I, Y, L, or M, at P3, P at P4, F or Y at P6)

5

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	10	ALLPAVPSL (SEQ ID NO:34)	100.000
2	332	KRYFKLSHL (SEQ ID NO:127)	48.000
3	126	RMFPNAPYL (SEQ ID NO:185)	36.000
4	3	SDVRDLNAL (SEQ ID NO:206)	30.000
5	239	NQMNLGATL (SEQ ID NO:151)	24.000
6	225	NLYQMTSQL (SEQ ID NO:147)	24.000
7	180	DPMGQQGSL (SEQ ID NO:59)	20.000
8	362	RRFSRSDQL (SEQ ID NO:187)	12.000
9	329	GCNKRYFKL (SEQ ID NO:90)	10.000
10	286	YRIHTHGVS (SEQ ID NO:252)	10.000
11	301	RRVPGVAPT (SEQ ID NO:189)	10.000
12	24	CALPVSGAA (SEQ ID NO:43)	10.000
13	136	SCLESQPAI (SEQ ID NO:198)	7.500
14	437	MHQRNMTKL (SEQ ID NO:143)	7.200

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
15	390	RKFSRSDHL (SEQ ID NO:183)	6.000
16	423	KKFARSDEL (SEQ ID NO:122)	6.000
17	92	FTVHFSGQF (SEQ ID NO:85)	5.000
18	429	DELVRHHNM (SEQ ID NO:53)	5.000
19	130	NAPYLPSC (SEQ ID NO:144)	4.800
20	30	GAAQWAPVL (SEQ ID NO:86)	4.000

Table XXXI

Results of BIMAS HLA Peptide Binding Prediction Analysis for

Binding of Human WT1 Peptides to Human HLA CW0401

(HLA-CW0401 peptide binding motif anchor residues are Y, P, or F at P2; L, F, or M at P9; auxiliary anchors are V, I, or L at P6)

5

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	356	DFKDCERRF (SEQ ID NO:55)	120.000
2	334	YFKLSHLOM (SEQ ID NO:248)	100.000
3	180	DPMGQQGSL (SEQ ID NO:59)	88.000
4	163	TPSHAAQF (SEQ ID NO:228)	52.800
5	327	YPGCNKRYF (SEQ ID NO:250)	40.000
6	285	OYRIHTHGV (SEQ ID NO:175)	27.500
7	424	KFARSDELV (SEQ ID NO:119)	25.000
8	326	AYPGCNKRY (SEQ ID NO:42)	25.000
9	192	QYSVPPPVY (SEQ ID NO:176)	25.000
10	417	RWPSCQKKF (SEQ ID NO:196)	22.000
11	278	TPILCGAQY (SEQ ID NO:227)	12.000
12	10	ALLPAVPSL (SEQ ID NO:34)	11.616
13	141	QPAIRNQG (SEQ ID NO:170)	11.000
14	303	VPGVAPTLV (SEQ ID NO:242)	11.000
15	219	TPYSSDNLV (SEQ ID NO:231)	10.000
16	39	DFAPPGASA (SEQ ID NO:54)	7.920
17	99	QFTGTAGAC (SEQ ID NO:165)	6.000
18	4	DVRDLNALL (SEQ ID NO:62)	5.760
19	70	SFIKQEPSW (SEQ ID NO:210)	5.500
20	63	PPPPPHSF (SEQ ID NO:158)	5.280

Table XXXII

Results of BIMAS HLA Peptide Binding Prediction Analysis for

Binding of Human WT1 Peptides to Human HLA CW0602

(HLA-CW0602 peptide binding motif anchor residues are L, I, V, or Y at P9;
auxiliary anchors are I, L, F, or M at P5, V, I, or L at P6)

5

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	332	KRYFKLSHL (SEQ ID NO:127)	9.680
2	239	NQMNLGATL (SEQ ID NO:151)	6.600
3	130	NAPYLPSC L (SEQ ID NO:144)	6.600
4	7	DLNALLPAV (SEQ ID NO:58)	6.000
5	441	NMTKLQLAL (SEQ ID NO:149)	6.000
6	225	NLYQMTSQL (SEQ ID NO:147)	6.000
7	4	DVRDLNALL (SEQ ID NO:62)	6.000
8	3	SDVRDLNAL (SEQ ID NO:206)	4.400
9	10	ALLPAVPSL (SEQ ID NO:34)	4.000
10	213	QALLRLTPY (SEQ ID NO:160)	3.300
11	319	EKRPFMCAY (SEQ ID NO:67)	3.000
12	30	GAAQWAPVL (SEQ ID NO:86)	2.200
13	242	NLGATLKG V (SEQ ID NO:146)	2.200
14	292	GVFRGIQDV (SEQ ID NO:103)	2.200
15	207	DSCTGSQAL (SEQ ID NO:61)	2.200
16	362	RRFSRS DQL (SEQ ID NO:187)	2.200
17	439	QRNMTKLQL (SEQ ID NO:173)	2.200
18	295	RGIQDVRRV (SEQ ID NO:179)	2.200
19	423	KKFARSD E L (SEQ ID NO:122)	2.200
20	180	DPMGQQGSL (SEQ ID NO:59)	2.200

Table XXXIII

Results of BIMAS HLA Peptide Binding Prediction Analysis for

Binding of Human WT1 Peptides to Human HLA CW0702

(HLA-CW0702 peptide binding motif anchor residues are Y, F, or L at P9;
auxiliary anchors are Y or P at P2, V, Y, I, L, F, or M at P5, V, I, L, or M at P6)

10

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	319	EKRPFMCAY (SEQ ID NO:67)	26.880
2	326	AYPGCNKRY (SEQ ID NO:42)	24.000
3	40	FAPPGASAY (SEQ ID NO:74)	14.784
4	192	QYSVPPPVY (SEQ ID NO:176)	12.000

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
5	278	TPILCGAQY (SEQ ID NO:227)	12.000
6	219	TPYSSDNLY (SEQ ID NO:231)	12.000
7	213	QALLLRTPY (SEQ ID NO:160)	8.800
8	125	ARMFPNAPY (SEQ ID NO:38)	8.000
9	327	YPGCNKRYF (SEQ ID NO:250)	6.600
10	152	VTFDGTPSY (SEQ ID NO:244)	5.600
11	141	QPAIRNQQY (SEQ ID NO:170)	4.800
12	345	RKHTGEKPY (SEQ ID NO:184)	4.000
13	185	QGSLEQQY (SEQ ID NO:166)	4.000
14	101	TGTAGACRY (SEQ ID NO:224)	4.000
15	375	RRHTGVKPF (SEQ ID NO:188)	4.000
16	263	GQSNHSTGY (SEQ ID NO:100)	4.000
17	163	TPSHHAAQF (SEQ ID NO:228)	3.000
18	33	QWAPVLDA (SEQ ID NO:174)	2.688
19	130	NAPYLPSC (SEQ ID NO:144)	2.640
20	84	HEEQCLSAF (SEQ ID NO:107)	2.400

Table XXXIV

Results of BIMAS HLA Peptide Binding Prediction Analysis for
Binding of Human WT1 Peptides to Mouse MHC Class I Db

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	235	CMTWNQMNL (SEQ ID NO:49)	5255.712
2	126	RMFPNAPYL (SEQ ID NO:185)	1990.800
3	221	YSSDNLYQM (SEQ ID NO:253)	930.000
4	228	QMTSQLECM (SEQ ID NO:169)	33.701
5	239	NQMNLGATL (SEQ ID NO:151)	21.470
6	441	NMTKLQAL (SEQ ID NO:149)	19.908
7	437	MHQRNMTKL (SEQ ID NO:143)	19.837
8	136	SCLESQPAI (SEQ ID NO:198)	11.177
9	174	HSFKHEDPM (SEQ ID NO:110)	10.800
10	302	RVPGVAPTL (SEQ ID NO:195)	10.088
11	130	NAPYLPSC (SEQ ID NO:144)	8.400
12	10	ALLPAVPSL (SEQ ID NO:34)	5.988
13	208	SCTGSQALL (SEQ ID NO:202)	4.435
14	209	CTGSQALL (SEQ ID NO:52)	3.548
15	238	WNQMNLGAT (SEQ ID NO:245)	3.300

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
16	218	RTPYSSDNL (SEQ ID NO:194)	3.185
17	24	CALPVSGAA (SEQ ID NO:43)	2.851
18	18	LGGGGGCAL (SEQ ID NO:134)	2.177
19	142	PAIRNQGY (SEQ ID NO:152)	2.160
20	30	GAAQWAPVL (SEQ ID NO:86)	1.680

Table XXXV

Results of BIMAS HLA Peptide Binding Prediction Analysis for
Binding of Human WT1 Peptides to Mouse MHC Class I Id

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	112	FGPPPPSQA (SEQ ID NO:76)	48.000
2	122	SGQARMFPN (SEQ ID NO:212)	36.000
3	104	AGACRYGPF (SEQ ID NO:31)	30.000
4	218	RTPYSSDNL (SEQ ID NO:194)	28.800
5	130	NAPYLPSC (SEQ ID NO:144)	20.000
6	302	RVPGVAPTL (SEQ ID NO:195)	20.000
7	18	LGGGGGCAL (SEQ ID NO:134)	20.000
8	81	AEPHEEQCL (SEQ ID NO:30)	10.000
9	29	SGAAQWAPV (SEQ ID NO:211)	7.200
10	423	KKFARSD (SEQ ID NO:122)	7.200
11	295	RGIQDVRRV (SEQ ID NO:179)	7.200
12	390	RKFSRSDHL (SEQ ID NO:183)	6.000
13	332	KRYFKLSHL (SEQ ID NO:127)	6.000
14	362	RRFSRSDQL (SEQ ID NO:187)	6.000
15	417	RWPSCQKKF (SEQ ID NO:196)	6.000
16	160	YGHTPSHHA (SEQ ID NO:249)	6.000
17	20	GGGGCALPV (SEQ ID NO:92)	6.000
18	329	GCNKRYFKL (SEQ ID NO:90)	5.000
19	372	RHQRRHTGV (SEQ ID NO:181)	4.500
20	52	GGPAPPAP (SEQ ID NO:93)	4.000

Table XXXVI

Results of BIMAS HLA Peptide Binding Prediction Analysis for
Binding of Human WT1 Peptides to Mouse MHC Class I Kb

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	329	GCNKRYFKL (SEQ ID NO:90)	24.000
2	225	NLYQMTSQL (SEQ ID NO:147)	10.000
3	420	SCQKKFARS (SEQ ID NO:200)	3.960
4	218	RTPYSSDNL (SEQ ID NO:194)	3.630
5	437	MHQRNMTKL (SEQ ID NO:143)	3.600
6	387	TCQRKFSRS (SEQ ID NO:219)	3.600
7	302	RVPGVAPTL (SEQ ID NO:195)	3.300
8	130	NAPYLPSCL (SEQ ID NO:144)	3.000
9	289	HTHGVFRGI (SEQ ID NO:113)	3.000
10	43	PGASAYGSL (SEQ ID NO:153)	2.400
11	155	DGTPSYGHT (SEQ ID NO:56)	2.400
12	273	SDNHTTPIL (SEQ ID NO:204)	2.200
13	126	RMFPNAPYL (SEQ ID NO:185)	2.200
14	128	FPNAPYLPS (SEQ ID NO:79)	2.000
15	3	SDVRDLNAL (SEQ ID NO:206)	1.584
16	207	DSCTGSQAL (SEQ ID NO:61)	1.584
17	332	KRYFKLSHL (SEQ ID NO:127)	1.500
18	18	LGGGGGCGAL (SEQ ID NO:134)	1.320
19	233	LECMTWNQM (SEQ ID NO:131)	1.320
20	441	NMTKLQAL (SEQ ID NO:149)	1.200

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Table XXXVII

Results of BIMAS HLA Peptide Binding Prediction Analysis for
Binding of Human WT1 Peptides to Mouse MHC Class I Kd

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	285	QYRIHTHGV (SEQ ID NO:175)	600.000
2	424	KFARSDDELV (SEQ ID NO:119)	288.000
3	334	YFKLSHLQM (SEQ ID NO:248)	120.000

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
4	136	SCLESQPTI (SEQ ID NO:199)	115.200
5	239	NQMNLGATL (SEQ ID NO:151)	115.200
6	10	ALLPAVSSL (SEQ ID NO:35)	115.200
7	47	AYGSLGGPA (SEQ ID NO:41)	86.400
8	180	DPMGQQGSL (SEQ ID NO:59)	80.000
9	270	GYESDNHTA (SEQ ID NO:105)	72.000
10	326	AYPGCNKRY (SEQ ID NO:42)	60.000
11	192	QYSVPPPVY (SEQ ID NO:176)	60.000
12	272	ESDNHTAPI (SEQ ID NO:70)	57.600
13	289	HTHGVFRGI (SEQ ID NO:113)	57.600
14	126	DVRDLNALL (SEQ ID NO:62)	57.600
15	4	CTGSQALLL (SEQ ID NO:52)	57.600
16	208	SCTGSQALL (SEQ ID NO:202)	48.000
17	441	NMTKLQAL (SEQ ID NO:149)	48.000
18	207	DSCTGSQAL (SEQ ID NO:61)	48.000
19	130	NAPYLPSC (SEQ ID NO:144)	48.000
20	235	CMTWNQMNL (SEQ ID NO:49)	48.000

Table XXXVIII

Results of BIMAS HLA Peptide Binding Prediction Analysis for
Binding of Human WT1 Peptides to Mouse MHC Class I Kk

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	81	AEPHEEQCL (SEQ ID NO:30)	40.000
2	85	EEQCLSAFT (SEQ ID NO:65)	40.000
3	429	DELVRHHNM (SEQ ID NO:53)	20.000
4	315	SETSEKRPF (SEQ ID NO:209)	20.000
5	261	TEGQSNHST (SEQ ID NO:221)	20.000
6	410	SEKPFSCRW (SEQ ID NO:207)	10.000
7	272	ESDNHTTPI (SEQ ID NO:71)	10.000
8	318	SEKRPFMCA (SEQ ID NO:208)	10.000
9	138	LESQPAIRN (SEQ ID NO:132)	10.000
10	233	LECMTWNQM (SEQ ID NO:131)	10.000
11	298	QDVRRVPGV (SEQ ID NO:164)	10.000
12	84	HEEQCLSAF (SEQ ID NO:107)	10.000
13	349	GEKPYQCDF (SEQ ID NO:91)	10.000
14	289	HTHGVFRGI (SEQ ID NO:113)	10.000

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
15	179	EDPMGQQGS (SEQ ID NO:64)	8.000
16	136	SCLESQPAI (SEQ ID NO:198)	5.000
17	280	ILCGAQYRI (SEQ ID NO:116)	5.000
18	273	SDNHTTPIL (SEQ ID NO:204)	4.000
19	428	SDELVRHHN (SEQ ID NO:203)	4.000
20	3	SDVRDLNAL (SEQ ID NO:206)	4.000

Table XXXIX

Results of BIMAS HLA Peptide Binding Prediction Analysis for
Binding of Human WT1 Peptides to Mouse MHC Class I Ld

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	163	TPSHHAAQF (SEQ ID NO:228)	360.000
2	327	YPGCNKRYF (SEQ ID NO:250)	300.000
3	180	DPMGQQGSL (SEQ ID NO:59)	150.000
4	26	LPVSGAAQW (SEQ ID NO:138)	93.600
5	278	TPILCGAQY (SEQ ID NO:227)	72.000
6	141	QPAIRNQGY (SEQ ID NO:170)	60.000
7	219	TPYSSDNLY (SEQ ID NO:231)	60.000
8	303	VPGVAPTLV (SEQ ID NO:242)	60.000
9	120	ASSGQARMF (SEQ ID NO:40)	50.000
10	63	PPPPPPHSF (SEQ ID NO:158)	45.000
11	113	GPPPPSQAS (SEQ ID NO:97)	45.000
12	157	TPSYGHTPS (SEQ ID NO:229)	39.000
13	207	DSCTGSQAL (SEQ ID NO:61)	32.500
14	110	GPFPPPPPS (SEQ ID NO:96)	30.000
15	82	EPHEEQCLS (SEQ ID NO:68)	30.000
16	412	KPFSCRWPS (SEQ ID NO:123)	30.000
17	418	WPSCQKKFA (SEQ ID NO:246)	30.000
18	221	YSSDNLYQM (SEQ ID NO:253)	30.000
19	204	TPTDCTGS (SEQ ID NO:230)	30.000
20	128	FPNAPYLPs (SEQ ID NO:79)	30.000

Table XL
Results of BIMAS HLA Peptide Binding Prediction Analysis for
Binding of Human WT1 Peptides to Cattle HLA A20

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	350	EKPYQCDFK (SEQ ID NO:66)	1000.00
2	319	EKRPFMCAY (SEQ ID NO:67)	500.000
3	423	KKFARSDDEL (SEQ ID NO:122)	500.000
4	345	RKHTGEKPY (SEQ ID NO:184)	500.000
5	390	RKFSRSDHL (SEQ ID NO:183)	500.000
6	137	CLESQPAIR (SEQ ID NO:47)	120.000
7	380	VKPFQCKTC (SEQ ID NO:239)	100.000
8	407	GKTSEKPF (SEQ ID NO:95)	100.000
9	335	FKLSHLQMH (SEQ ID NO:78)	100.000
10	247	LKGVAAGSS (SEQ ID NO:135)	100.000
11	370	LKRHRHRT (SEQ ID NO:136)	100.000
12	258	VKWTEGQSN (SEQ ID NO:240)	100.000
13	398	LKTHTRTHT (SEQ ID NO:137)	100.000
14	331	NKRYFKLSH (SEQ ID NO:145)	100.000
15	357	FKDCERRFS (SEQ ID NO:77)	100.000
16	385	CKTCQRKFS (SEQ ID NO:46)	100.000
17	294	FRGIQDVRR (SEQ ID NO:81)	80.000
18	368	DOLKRHRHRT (SEQ ID NO:60)	80.000
19	432	VRHHNMHQR (SEQ ID NO:243)	80.000
20	118	SQASSGQAR (SEQ ID NO:216)	80.000

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Table XLI
Results of BIMAS HLA Peptide Binding Prediction Analysis for
Binding of Mouse WT1 Peptides to Human HLA A 0201

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	126	RMFPNAPYL (SEQ ID NO:293)	313.968
2	187	SLGEQQYSV (SEQ ID NO:299)	285.163
3	10	ALLPAVSSL (SEQ ID NO:255)	181.794
4	225	NLYQMTSQL (SEQ ID NO:284)	68.360
5	292	GVFRGIQDV (SEQ ID NO:270)	51.790
6	93	TLHFSGQFT (SEQ ID NO:302)	40.986

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
7	191	QQYSVPPP (SEQ ID NO:290)	22.566
8	280	ILCGAQYRI (SEQ ID NO:274)	17.736
9	441	NMTKLHVAL (SEQ ID NO:285)	15.428
10	235	CMTWNQMNL (SEQ ID NO:258)	15.428
11	7	DLNALLPAV (SEQ ID NO:261)	11.998
12	242	NLGATLKGM (SEQ ID NO:283)	11.426
13	227	YQMTSQLE (SEQ ID NO:307)	8.573
14	239	NQMNLGATL (SEQ ID NO:286)	8.014
15	309	TLVRSASET (SEQ ID NO:303)	7.452
16	408	KTSEKPFSC (SEQ ID NO:277)	5.743
17	340	LQMHSRKHT (SEQ ID NO:280)	4.752
18	228	QMTSQLECM (SEQ ID NO:289)	4.044
19	37	VLDFAAPGA (SEQ ID NO:304)	3.378
20	302	RVSGVAPTL (SEQ ID NO:295)	1.869

Table XLII

Results of BIMAS HLA Peptide Binding Prediction Analysis for
Binding of Mouse WT1 Peptides to Mouse MHC Class I Db

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	221	YSSDNLQYM (SEQ ID NO:308)	312.000
2	126	RMFPNAPYL (SEQ ID NO:293)	260.000
3	235	CMTWNQMNL (SEQ ID NO:258)	260.000
4	437	MHQNRNMTKL (SEQ ID NO:281)	200.000
5	238	WNQMNLGAT (SEQ ID NO:305)	12.000
6	130	NAPYLPSC (SEQ ID NO:282)	8.580
7	3	SDVRDLNAL (SEQ ID NO:298)	7.920
8	136	SCLESQPTI (SEQ ID NO:296)	7.920
9	81	AEPHEEQCL (SEQ ID NO:254)	6.600
10	10	ALLPAVSSL (SEQ ID NO:255)	6.600
11	218	RTPYSSDNL (SEQ ID NO:294)	6.000
12	441	NMTKLHVAL (SEQ ID NO:285)	3.432
13	228	QMTSQLECM (SEQ ID NO:289)	3.120
14	174	HSFKHEDPM (SEQ ID NO:272)	3.120
15	242	NLGATLKGM (SEQ ID NO:283)	2.640
16	261	TEGQSNHGI (SEQ ID NO:301)	2.640
17	225	NLYQMTSQL (SEQ ID NO:284)	2.640

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
18	207	DSCTGSQAL (SEQ ID NO:263)	2.600
19	119	QASSGQARM (SEQ ID NO:288)	2.600
20	18	LGGGGGCGL (SEQ ID NO:279)	2.600

Table XLIII

Results of BIMAS HLA Peptide Binding Prediction Analysis for
Binding of Mouse WT1 Peptides to Mouse MHC Class I Kb

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	329	GCNKRYFKL (SEQ ID NO:268)	24.000
2	225	NLYQMTSQL (SEQ ID NO:284)	10.000
3	420	SCQKKFARS (SEQ ID NO:297)	3.960
4	218	RTPYSSDNL (SEQ ID NO:294)	3.630
5	437	MHQRNMTKL (SEQ ID NO:281)	3.600
6	387	TCQRKFSRS (SEQ ID NO:300)	3.600
7	289	HTHGVFRGI (SEQ ID NO:273)	3.000
8	130	NAPYLPSC (SEQ ID NO:282)	3.000
9	43	PGASAYGSL (SEQ ID NO:287)	2.400
10	155	DGAPSYGHT (SEQ ID NO:260)	2.400
11	126	RMFPNAPYL (SEQ ID NO:293)	2.200
12	128	FPNAPYLP (SEQ ID NO:267)	2.000
13	207	DSCTGSQAL (SEQ ID NO:263)	1.584
14	3	SDVRDLNAL (SEQ ID NO:298)	1.584
15	332	KRYFKLSHL (SEQ ID NO:276)	1.500
16	233	LECMTWNQM (SEQ ID NO:278)	1.320
17	18	LGGGGGCGL (SEQ ID NO:279)	1.320
18	242	NLGATLKGM (SEQ ID NO:283)	1.200
19	123	GQARMFPN (SEQ ID NO:269)A	1.200
20	441	NMTKLHVAL (SEQ ID NO:285)	1.200

Table XLIV
Results of BIMAS HLA Peptide Binding Prediction Analysis for
Binding of Mouse WT1 Peptides to Mouse MHC Class I Kd

Rank	Start Position	Subsequence Residue Listing	Score (Estimate of Half Time of Disassociation of a Molecule Containing This Subsequence)
1	285	QYRIHTHGV (SEQ ID NO:291)	600.000
2	424	KFARSDELV (SEQ ID NO:275)	288.000
3	334	YFKLSHLQM (SEQ ID NO:306)	120.000
4	136	SCLESOPTI (SEQ ID NO:296)	115.200
5	239	NQMNLGATL (SEQ ID NO:286)	115.200
6	10	ALLPAVSSL (SEQ ID NO:255)	115.200
7	47	AYGSLGGPA (SEQ ID NO:256)	86.400
8	180	DPMGQGGSL (SEQ ID NO:262)	80.000
9	270	GYESDNHTA (SEQ ID NO:271)	72.000
10	192	QYSVPPPVY (SEQ ID NO:292)	60.000
11	326	AYPGCNKRY (SEQ ID NO:257)	60.000
12	289	HTHGVFRGI (SEQ ID NO:273)	57.600
13	4	DVRDLNALL (SEQ ID NO:264)	57.600
14	126	RMFPNAPYL (SEQ ID NO:293)	57.600
15	209	CTGSQALLL (SEQ ID NO:259)	48.000
16	86	EOCLSAFTL (SEQ ID NO:265)	48.000
17	302	RVSGVAPTL (SEQ ID NO:295)	48.000
18	218	RTPYSSDNL (SEQ ID NO:294)	48.000
19	272	ESDNHTAPI (SEQ ID NO:266)	48.000
20	225	NLYQMTSQL (SEQ ID NO:284)	48.000

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Table XLV
Results of TSites Peptide Binding Prediction Analysis for
Human WT1 Peptides Capable of Eliciting a Helper T cell Response

Peptide	Sequence
p6-23	RDLNALLPAVPSLGGGG (SEQ ID NO:1)
p30-35	GAAQWA (SEQ ID NO:309)
p45-56	ASAYGSLGGPAP (SEQ ID NO:310)
p91-105	AFTVHFSGQFTGTAG (SEQ ID NO:311)
p117-139	PSQASSGQARMFPNAPYLPSCLE (SEQ ID NO:2)
p167-171	HAAQF (SEQ ID NO:312)
p202-233	CHTPDTSCTGSQALLRTPYSSDNLQMTSQL (SEQ ID NO:313)
p244-262	GATLKGVAAGSSSSVKWTE (SEQ ID NO:4)

Peptide	Sequence
p287-318	RIHTHGVFRGIQDVRRVPGVAPTLVRSASETS (SEQ ID NO:314)
p333-336	RYFK (SEQ ID NO:315)
p361-374	ERRFSRSDQLKRHQ (SEQ ID NO:316)
p389-410	QRKFSSRDHLKTHTRHTGKTS (SEQ ID NO:317)
p421-441	CQKFFARSDLVRRHHNMHQRN (SEQ ID NO:318)

Certain CTL peptides (shown in Table XLVI) were selected for further study. For each peptide in Table XLVI, scores obtained using BIMAS HLA peptide binding prediction analysis are provided.

5

Table XLVIWT1 Peptide Sequences and HLA Peptide Binding Predictions

Peptide	Sequence	Comments
p329-337	GCNKRYFKL (SEQ ID NOs: 90 and 268)	Score 24,000
p225-233	NLYQMTSQL (SEQ ID NOs: 147 and 284)	binds also to class II and HLA A2, Kd, score 10,000
p235-243	CMTWNQMNL (SEQ ID NOs: 49 and 258)	binds also to HLA A2, score 5,255,712
p126-134	RMFPNAPYL (SEQ ID NOs: 185 and 293)	binds also to Kd, class II and HLA A2, score 1,990,800
p221-229	YSSDONLYQM (SEQ ID NOs: 253 and 308)	binds also to Ld, score 312,000
p228-236	QMTSQLECM (SEQ ID NOs: 169 and 289)	score 3,120
p239-247	NQMNLGATL (SEQ ID NOs: 151 and 286)	binds also to HLA A 0201, Kd, score 8,015
mouse p136-144	SCLESQPTI (SEQ ID NO:296)	binds also to Kd, 1mismatch to human
human p136-144	SCLESQPAI (SEQ ID NO:198)	score 7,920
mouse p10-18	ALLPAVSSL (SEQ ID NO:255)	binds also to Kd, HLA A2,, 1 mismatch to human
human p10-18	ALLPAVPSL (SEQ ID NO:34)	score 6,600

- Peptide binding to C57B/6 murine MHC was confirmed using the leukemia cell line RMA-S, as described by Ljunggren et al., *Nature* 346:476-480, 1990. In brief, RMA-S cells were cultured for 7 hours at 26°C in complete medium supplemented with 1% FCS. A total of 10^6 RMA-S cells were added
- 5 into each well of a 24-well plate and incubated either alone or with the designated peptide (25ug/ml) for 16 hours at 26°C and additional 3 hours at 37°C in complete medium. Cells were then washed three times and stained with fluorescein isothiocyanate-conjugated anti D^b or anti-K^b antibody (PharMingen, San Diego, CA). Labeled cells were washed twice, resuspended
- 10 and fixed in 500ul of PBS with 1% paraformaldehyde and analyzed for fluorescence intensity in a flow cytometer (Becton-Dickinson FACSCalibur®). The percentage of increase of D^b or K^b molecules on the surface of the RMA-S cells was measured by increased mean fluorescent intensity of cells incubated with peptide compared with that of cells incubated in medium alone.
- 15 Mice were immunized with the peptides capable of binding to murine class I MHC. Following immunization, spleen cells were stimulated *in vitro* and tested for the ability to lyse targets incubated with WT1 peptides. CTL were evaluated with a standard chromium release assay (Chen et al., *Cancer Res.* 54:1065-1070, 1994). 10^6 target cells were incubated at 37°C with
- 20 150μCi of sodium ⁵¹Cr for 90 minutes, in the presence or absence of specific peptides. Cells were washed three times and resuspended in RPMI with 5% fetal bovine serum. For the assay, 10^4 ⁵¹Cr-labeled target cells were incubated with different concentrations of effector cells in a final volume of 200μl in U-bottomed 96-well plates. Supernatants were removed after 4 to 7 hours at
- 25 37°C, and the percentage specific lysis was determined by the formula:
% specific lysis = $100 \times (\text{experimental release} - \text{spontaneous release}) / (\text{maximum release} - \text{spontaneous release})$.

The results, presented in Table XLVII, show that some WT1 peptides can bind to class I MHC molecules, which is essential for generating

30 CTL. Moreover, several of the peptides were able to elicit peptide specific CTL (Figures 9A and 9B), as determined using chromium release assays. Following

immunization to CTL peptides p10-18 human, p136-144 human, p136-144 mouse and p235-243, peptide specific CTL lines were generated and clones were established. These results indicate that peptide specific CTL can kill malignant cells expressing WT1.

5

Table XLVIIBinding of WT1 CTL Peptides to mouse B6 class I antigens

Peptide	Binding Affinity to Mouse MHC Class I
Positive control	91%
negative control	0.5-1.3%
p235-243	33.6%
p136-144 mouse	27.9%
p136-144 human	52%
p10-18: human	2.2%
p225-233	5.8%
p329-337	1.2%
p126-134	0.9%
p221-229	0.8%
p228-236	1.2%
p239-247	1%

EXAMPLE 5**USE OF A WT1 POLYPEPTIDE TO ELICIT WT1 SPECIFIC CTL IN MICE**

10

This Example illustrates the ability of a representative WT1 polypeptide to elicit CTL immunity capable of killing WT1 positive tumor cell lines.

- P117-139, a peptide with motifs appropriate for binding to class I and class II MHC, was identified as described above using TSITES and BIMAS
- 15 HLA peptide binding prediction analyses. Mice were immunized as described in Example 3. Following immunization, spleen cells were stimulated *in vitro* and tested for the ability to lyse targets incubated with WT1 peptides, as well as WT1 positive and negative tumor cells. CTL were evaluated with a standard chromium release assay. The results, presented in Figures 10A-10D, show
- 20 that P117 can elicit WT1 specific CTL capable of killing WT1 positive tumor cells, whereas no killing of WT1 negative cells was observed. These results demonstrate that peptide specific CTL in fact kill malignant cells expressing

WT1 and that vaccine and T cell therapy are effective against malignancies that express WT1.

Similar immunizations were performed using the 9-mer class I MHC binding peptides p136-144, p225-233, p235-243 as well as the 23-mer peptide p117-139. Following immunization, spleen cells were stimulated *in vitro* with each of the 4 peptides and tested for ability to lyse targets incubated with WT1 peptides. CTL were generated specific for p136-144, p235-243 and p117-139, but not for p225-233. CTL data for p235-243 and p117-139 are presented in Figures 11A and 11B. Data for peptides p136-144 and p225-233 are not depicted.

CTL lysis demands that the target WT1 peptides are endogenously processed and presented in association with tumor cell class I MHC molecules. The above WT1 peptide specific CTL were tested for ability to lyse WT1 positive versus negative tumor cell lines. CTL specific for p235-243 lysed targets incubated with the p235-243 peptides, but failed to lyse cell lines that expressed WT1 proteins (Figure 11A). By marked contrast, CTL specific for p117-139 lysed targets incubated with p117-139 peptides and also lysed malignant cells expressing WT1 (Figure 11B). As a negative control, CTL specific for p117-139 did not lyse WT1 negative EL-4 (also referred to herein as E10).

Specificity of WT1 specific lysis was confirmed by cold target inhibition (Figures 12A-12B). Effector cells were plated for various effector: target ratios in 96-well U-bottom plates. A ten-fold excess (compared to hot target) of the indicated peptide-coated target without ^{51}Cr labeling was added. Finally, 10^4 ^{51}Cr -labeled target cells per well were added and the plates incubated at 37°C for 4 hours. The total volume per well was $200\mu\text{l}$.

Lysis of TRAMP-C by p117-139 specific CTL was blocked from 58% to 36% by EL-4 incubated with the relevant peptide p117-139, but not with EL-4 incubated with an irrelevant peptide (Figure 12A). Similarly, lysis of BLK-SV40 was blocked from 18% to 0% by EL-4 incubated with the relevant peptide

p117-139 (Figure 12B). Results validate that WT1 peptide specific CTL specifically kill malignant cells by recognition of processed WT1.

Several segments with putative CTL motifs are contained within p117-139. To determine the precise sequence of the CTL epitope all potential 9-mer peptides within p117-139 were synthesized (Table XLVIII). Two of these peptides (p126-134 and p130-138) were shown to bind to H-2^b class I molecules (Table XLVIII). CTL generated by immunization with p117-139 lysed targets incubated with p126-134 and p130-138, but not the other 9-mer peptides within p117-139 (Figure 13A).

The p117-139 specific CTL line was restimulated with either p126-134 or p130-138. Following restimulation with p126-134 or p130-138, both T cell lines demonstrated peptide specific lysis, but only p130-138 specific CTL showed lysis of a WT1 positive tumor cell line (Figures 13B and 13C). Thus, p130-138 appears to be the naturally processed epitope.

Table XLVIII

Binding of WT1 CTL 9mer Peptides within p117-139 to mouse B6 class I antigens

Peptide	Binding Affinity to Mouse MHC Class I
P117-125 PSQASSGQA (SEQ ID NO:221)	2%
P118-126 SQASSGQAR (SEQ ID NO:216)	2%
P119-127 QASSGQARM (SEQ ID Nos: 161 and 288)	2%
P120-128 ASSGQARMF (SEQ ID NO:40)	1%
P121-129 SSGQARMFP (SEQ ID NO:222)	1%
P122-130 SGQARMFPN (SEQ ID NO:212)	1%
P123-131 GQARMFPNA (SEQ ID Nos: 98 and 269)	1%
P124-132 QARMFPNAP (SEQ ID NO:223)	1%
P125-133 ARMFPNAPY (SEQ ID NO:38)	1%
P126-134 RMFPNAPYL (SEQ ID NOs: 185 and 293)	79%
P127-135 MFPNAPYLP (SEQ ID NO:224)	2%
P128-136 FPNAPYLPS (SEQ ID NOs: 79 and 267)	1%
P129-137 PNAPYLPSC (SEQ ID NO:225)	1%
P130-138 NAPYLPSCLE (SEQ ID NOs: 144 and 282)	79%
P131-139 APYLPSCLE (SEQ ID NO:226)	1%

EXAMPLE 6

IDENTIFICATION OF WT1 SPECIFIC mRNA IN MOUSE TUMOR CELL LINES

This Example illustrates the use of RT-PCR to detect WT1 specific mRNA in cells and cell lines.

- 5 Mononuclear cells were isolated by density gradient centrifugation, and were immediately frozen and stored at -80°C until analyzed by RT-PCR for the presence of WT1 specific mRNA. RT-PCR was generally performed as described by Fraizer et al., *Blood* 86:4704-4706, 1995. Total RNA was extracted from 10⁷ cells according to standard procedures. RNA
10 pellets were resuspended in 25 µL diethylpyrocarbonate treated water and used directly for reverse transcription. The zinc-finger region (exons 7 to 10) was amplified by PCR as a 330 bp mouse cDNA. Amplification was performed in a thermocycler during one or, when necessary, two sequential rounds of PCR. AmpliTaq DNA Polymerase (Perkin Elmer Cetus, Norwalk, CT), 2.5 mM
15 MgCl₂ and 20 pmol of each primer in a total reaction volume of 50 µl were used. Twenty µL aliquots of the PCR products were electrophoresed on 2% agarose gels stained with ethidium bromide. The gels were photographed with Polaroid film (Polaroid 667, Polaroid Ltd., Hertfordshire, England). Precautions against cross contamination were taken following the recommendations of Kwok and
20 Higuchi, *Nature* 339:237-238, 1989. Negative controls included the cDNA- and PCR-reagent mixes with water instead of cDNA in each experiment. To avoid false negatives, the presence of intact RNA and adequate cDNA generation was evaluated for each sample by a control PCR using β-actin primers. Samples that did not amplify with these primers were excluded from analysis.
- 25 Primers for amplification of WT1 in mouse cell lines were: P115: 1458-1478: 5' CCC AGG CTG CAA TAA GAG ATA 3' (forward primer; SEQ ID NO:21); and P116: 1767-1787: 5' ATG TTG TGA TGG CGG ACC AAT 3' (reverse primer; SEQ ID NO:22) (see Inoue et al, *Blood* 88:2267-2278, 1996; Fraizer et al., *Blood* 86:4704-4706, 1995).

Beta Actin primers used in the control reactions were: 5' GTG GGG CGC CCC AGG CAC CA 3' (sense primer; SEQ ID NO:23); and 5' GTC CTT AAT GTC ACG CAC GAT TTC 3' (antisense primer; SEQ ID NO:24)

Primers for use in amplifying human WT1 include: P117: 954-

- 5 974: 5' GGC ATC TGA GAC CAG TGA GAA 3' (SEQ ID NO:25); and P118: 1434-1414: 5' GAG AGT CAG ACT TGA AAG CAGT 3' (SEQ ID NO:5). For nested RT-PCR, primers may be: P119: 1023-1043: 5' GCT GTC CCA CTT ACA GAT GCA 3' (SEQ ID NO:26); and P120: 1345-1365: 5' TCA AAG CGC CAG CTG GAG TTT 3' (SEQ ID NO:27).

- 10 Table XLVIII shows the results of WT1 PCR analysis of mouse tumor cell lines. Within Table IV, (+++) indicates a strong WT1 PCR amplification product in the first step RT PCR, (++) indicates a WT1 amplification product that is detectable by first step WT1 RT PCR, (+) indicates a product that is detectable only in the second step of WT1 RT PCR, and (-) indicates WT1 PCR negative.

Table XLIX

Detection of WT1 mRNA in Mouse Tumor Cell Lines

Cell Line	WT1 mRNA
K562 (human leukemia; ATCC): Positive control; (Lozzio and Lozzio, <i>Blood</i> 45:321-334, 1975)	+++
TRAMPC (SV40 transformed prostate, B6); Foster et al., <i>Cancer Res.</i> 57:3325-3330, 1997	+++
BLK-SV40 HD2 (SV40-transf. fibroblast, B6; ATCC); <i>Nature</i> 276:510-511, 1978	++
CTLL (T-cell, B6; ATCC); Gillis, <i>Nature</i> 268:154-156, 1977	+
FM (FBL-3 subline, leukemia, B6); Glynn and Fefer, <i>Cancer Res.</i> 28:434-439, 1968	+
BALB 3T3 (ATCC); Aaroston and Todaro, <i>J. Cell. Physiol.</i> 72:141-148, 1968	+
S49.1 (Lymphoma, T-cell like, B/C; ATCC); Horibata and Harris, <i>Exp. Cell. Res.</i> 60:61, 1970	+
BNL CL2 (embryonic liver, B/C; ATCC); <i>Nature</i> 276:510-511, 1978	+
MethA (sarcoma, B/C); Old et al., <i>Ann. NY Acad. Sci.</i> 101:80-106, 1962	-

Cell Line	WT1 mRNA
P3.6.2.8.1 (myeloma, B/C; ATCC); <i>Proc. Natl. Acad. Sci. USA</i> 66:344, 1970	-
P2N (leukemia, DBA/2; ATCC); Melling et al., <i>J. Immunol.</i> 117:1267-1274, 1976	-
BCL1 (lymphoma, B/C; ATCC); Slavin and Strober, <i>Nature</i> 272:624-626, 1977	-
LSTRA (lymphoma, B/C); Glynn et al., <i>Cancer Res.</i> 28:434-439, 1968	-
E10/EL-4 (lymphoma, B6); Glynn et al., <i>Cancer Res.</i> 28:434-439, 1968	-

EXAMPLE 7

EXPRESSION IN E. COLI OF WT1 TRX FUSION CONSTRUCT

The truncated open reading frame of WT1 (WT1B) was PCR

- 5 amplified with the following primers:

Forward Primer starting at amino acid 2

P-37 (SEQ ID NO. 342) 5' ggctccgacgtgcgggacctg 3' Tm 64°C

Reverse Primer creating EcoRI site after stop codon

P-23 (SEQ ID NO. 343) 5' gaattctcaaagcgcagctggagtttggt 3'

10

Tm 63°C

The PCR was performed under the following conditions:

10µl 10X Pfu buffer

1µl 10mM dNTPs

2µl 10µM each oligo

15

83µL sterile water

1.5µl Pfu DNA polymerase (Stratagene, La Jolla, CA)

50 ng DNA (pPDM FL WT1)

96°C 2 minutes

96°C 20 seconds 63°C 15 seconds 72°C 3 minutes x 40

20

cycles

72°C 4 minutes

The PCR product was digested with EcoRI restriction enzyme, gel purified and then cloned into pTrx 2H vector (a modified pET28 vector with a Trx fusion on the N-terminal and two His tags surrounding the Trx fusion. After the Trx fusion there exists protease cleavage sites for thrombin and enterokinase). The pTrx2H construct was digested with StuI and EcoRI
 5 restriction enzymes. The correct constructs were confirmed by DNA sequence analysis and then transformed into BL21 (DE3) pLys S and BL21 (DE3) CodonPlus expression host cells.

10

EXAMPLE 8

EXPRESSION IN E. COLI OF WT1 A HIS TAG FUSION CONSTRUCTS

The N-terminal open reading frame of WT1 (WT1A) was PCR amplified with the following primers:

Forward Primer starting at amino acid 2
 15 P-37 (SEQ ID NO. 344) 5'ggctccgacgtgccggacctg 3' Tm 64°C
 Reverse Primer creating EcoRI site after an artificial stop codon
 put after amino acid 249.
 PDM-335 (SEQ ID NO. 345)
 5'gaattctcaaagcgccagctggagtttgt 3' Tm 64°C
 20 The PCR was performed under the following conditions:
 10µl 10X Pfu buffer
 1µl 10mM dNTPs
 2µl 10µM each oligo
 83µL sterile water
 25 1.5µl Pfu DNA polymerase (Stratagene, La Jolla, CA)
 50 ng DNA (pPDM FL WT1)
 96°C 2 minutes
 96°C 20 seconds 63°C 15 seconds 72°C 1 minute 20
 seconds x
 30 40 cycles
 72°C 4 minutes

The PCR product was digested with EcoRI restriction enzyme, gel purified and then cloned into pPDM, a modified pET28 vector with a His tag in frame, which had been digested with Eco72I and EcoRI restriction enzymes. The PCR product was also transformed into pTrx 2H vector. The pTrx2H
 5 construct was digested with Stul and EcoRI restriction enzymes. The correct constructs were confirmed by DNA sequence analysis and then transformed into BL21 (DE3) pLys S and BL21 (DE3) CodonPlus expression host cells.

EXAMPLE 9

EXPRESSION IN E. COLI OF WT1 B HIS TAG FUSION CONSTRUCTS

10 The truncated open reading frame of WT1 (WT1A) was PCR amplified with the following primers:

Forward Primer starting at amino acid 250

PDM-346 (SEQ ID NO. 346) 5' cacagcacagggtacgagagc 3'

Tm 58°C

15 Reverse Primer creating EcoRI site after stop codon

P-23 (SEQ ID NO. 347) 5'gaattctcaaagccagctggagttggt 3'

Tm 63°C

The PCR was performed under the following conditions:

10µl 10X Pfu buffer

20 1µl 10mM dNTPs

2µl 10µM each oligo

83µL sterile water

1.5µl Pfu DNA polymerase (Stratagene, La Jolla, CA)

50 ng DNA (pPDM FL WT1)

25 96°C 2 minutes

96°C 20 seconds 63°C 15 seconds 72°C 1 minute 30
seconds x

40 cycles

72°C 4 minutes

The PCR product was digested with EcoRI restriction enzyme, gel purified and then cloned into pPDM, a modified pET28 vector with a His tag in frame, which had been digested with Eco72I and EcoRI restriction enzymes.

- The PCR product was also transformed into pTrx 2H vector. The pTrx 2H construct was digested with StuI and EcoRI restriction enzymes. The correct constructs were confirmed by DNA sequence analysis and then transformed into BL21 (DE3) pLys S and BL21 (DE3) CodonPlus expression host cells.

For Examples 7-9, the following SEQ ID NOs. are disclosed:

- SEQ ID NO. 327 is the determined cDNA sequence for Trx_WT1_B
 10 SEQ ID NO. 328 is the determined cDNA sequence for Trx_WT1_A
 SEQ ID NO. 329 is the determined cDNA sequence for Trx_WT1
 SEQ ID NO. 330 is the determined cDNA sequence for WT1_A
 SEQ ID NO. 331 is the determined cDNA sequence for WT1_B
 SEQ ID NO. 332 is the predicted amino acid sequence encoded by SEQ ID No.
 15 327
 SEQ ID NO. 333 is the predicted amino acid sequence encoded by SEQ ID No. 328
 SEQ ID NO. 334 is the predicted amino acid sequence encoded by SEQ ID No. 329
 20 SEQ ID NO. 335 is the predicted amino acid sequence encoded by SEQ ID No. 330
 SEQ ID NO. 336 is the predicted amino acid sequence encoded by SEQ ID No. 331

25

EXAMPLE 10

TRUNCATED FORMS OF WT1 EXPRESSED IN E. COLI

Three reading frames of WT1 were amplified by PCR using the following primers:

For WT1 Tr2:

30

PDM-441 (SEQ ID NO. 348) 5'
 cacgaagaacagtcgctgagcgcattcac 3' Tm 63°C

PDM-442 (SEQ ID NO. 349) 5'

ccggcgaattcatcagtataaattgtcactgc 3' Tm 62°C

For WT1 Tr3:

PDM-443 (SEQ ID NO. 350) 5'

caggcttctgctgctgaggacgcc 3' Tm 64°C

PDM-444 (SEQ ID NO. 351) 5'

cacggagaattcatcactggtatggtttctacc Tm 64°C

For WT1 Tr4:

PDM-445 (SEQ ID NO. 352) 5'

cacagcaggaagcacactggtgagaaac 3' Tm 63°C

PDM-446 (SEQ ID NO. 353) 5'

ggatatctgcagaattctcaaagcgccagc 3' Tm 63°C

The PCR was performed under the following conditions:

10µl 10X Pfu buffer

1µl 10mM dNTPs

2µl 10µM each oligo

83µL sterile water

1.5µl Pfu DNA polymerase (Stratagene, La Jolla, CA)

50 ng DNA (pPDM FL WT1)

96°C 2 minutes

96°C 20 seconds 63°C 15 seconds 72°C 30 seconds x 40 cycles

72°C 4 minutes

The PCR products were digested with EcoRI and cloned into

- 25 pPDM His (a modified pET28 vector with a His tag in frame on the 5' end) which has been digested with Eco72I and EcoRI. The constructs were confirmed to be correct through sequence analysis and transformed into BL21 pLys S and BL21 CodonPlus cells or BLR pLys S and BLR CodonPlus cells.

EXAMPLE 11

WT1 C (amino acids 76-437) AND WT1 D (amino acids 91-437) EXPRESSION IN
E. COLI

The WT1 C reading frame was amplified by PCR using the
5 following primers:

PDM-504 (SEQ ID NO. 354) 5' cactccttcatcaaacaggaac 3'
Tm 61°C

PDM-446 (SEQ ID NO. 355) 5'
ggatatctgcagaattctcaaagcgccagc 3' Tm 63°C

10 The PCR was performed under the following conditions:

10µl 10X Pfu buffer

1µl 10mM dNTPs

2µl 10µM each oligo

83µL sterile water

15 1.5µl Pfu DNA polymerase (Stratagene, La Jolla, CA)

50 ng DNA (pPDM FL WT1)

96°C 2 minutes

96°C 20 seconds 63°C 15 seconds 72°C 2 minutes x 40
cycles

20 72°C 4 minutes

The PCR product was digested with EcoRI and cloned into pPDM
His which had been digested with Eco72I and EcoRI. The sequence was
confirmed through sequence analysis and then transformed into BLR pLys S
and BLR which is co-transformed with CodonPlus RP.

25

EXAMPLE 12

SYNTHETIC PRODUCTION OF WT1 TR-1 BY ANNEALING OVERLAPPING OLIGOS

This example was performed to determine the effect of changing
proline codon usage on expression.

30 The following pairs of oligos were annealed:

1. PDM-505 (SEQ ID NO. 356) 5'
gggtccgacgtgcgggacctgaacgcactgctg 3'
- PDM-506 (SEQ ID NO. 357) 5'
ctgccggcagcagtgcggtcagggtccgcacgtcggaacc 3'
- 5 2. PDM-507 (SEQ ID NO. 358) 5'
ccggcagttccatccctgggtggcggtggaggctg 3'
- PDM-508 (SEQ ID NO. 359) 5'
cggcagtgccagcctccaccgccaccagggtggaa 3'
- 10 3. PDM-509 (SEQ ID NO. 360) 5'
cgactgccggttagcgggtgcagcacagtgggctc 3'
- PDM-510 (SEQ ID NO. 361) 5'
cagaactggagcccactgtgctgcaccgctaac 3'
- 15 4. PDM-511 (SEQ ID NO. 362) 5'
cagttctggacttcgcaccgcctgtgcatccgcatac 3'
- PDM-512 (SEQ ID NO. 363) 5'
caggggaaccgtatgcggatgcaccaggcggtgcgaagtc 3'
- 20 5. PDM-513 (SEQ ID NO. 364) 5'
ggttccctgggtgggtccagcacctccgcccgaacgcc 3'
- PDM-514 (SEQ ID NO. 365) 5'
ggcgggtggggcggttcggggcggagggtgctggaccacc 3'
- 25 6. PDM-515 (SEQ ID NO. 366) 5'
cccaccgctccaccgccccgcactccttcatcaaacag 3'
- PDM-516 (SEQ ID NO. 367) 5'
ctaggttcctgtttgatgaaggagtgccggggcggtgga 3'
7. PDM-517 (SEQ ID NO. 368) 5'
gaacctagctgggtgggtgcagaaccgcacgaagaaca 3'
- PDM-518 (SEQ ID NO. 369) 5'
ctcagggcactgttctctgtgcggttctgcaccacccag 3'

8. PDM-519 (SEQ ID NO. 370) 5'
 gtgcctgagcgcattctgagaattctgcagat 3'
 PDM-520 (SEQ ID NO. 371) 5'
 gtgtgatggatatctgcagaattctcagaatgcg 3'

5 Each oligo pair was separately combined then annealed. The pairs were then ligated together and one μ l of ligation mix was used for PCR conditions below:

10 10 μ l 10X Pfu buffer
 1 μ l 10mM dNTPs
 2 μ l 10 μ M each oligo
 83 μ L sterile water
 1.5 μ l Pfu DNA polymerase (Stratagene, La Jolla, CA)
 96°C 2 minutes
 96°C 20 seconds 63°C 15 seconds 72°C 30 seconds x 40
 15 cycles
 72°C 4 minutes

The PCR product was digested with EcoRI and cloned into pPDM His which had been digested with Eco72I and EcoRI. The sequence was confirmed and then transformed into BLR pLys S and BLR which is co-
 20 transformed with CodonPlus RP.

For examples 10-12, the following SEQ ID NOs. are disclosed:

SEQ ID NO:337 is the determined cDNA sequence for WT1_Tr1
 SEQ ID NO:338 is the determined cDNA sequence for WT1_Tr2
 SEQ ID NO:339 is the determined cDNA sequence for WT1_Tr3
 25 SEQ ID NO:340 is the determined cDNA sequence for WT1_Tr4
 SEQ ID NO:341 is the determined cDNA sequence for WT1_C
 SEQ ID NO:342 is the predicted amino acid sequence encoded by SEQ ID NO:337
 SEQ ID NO:343 is the predicted amino acid sequence encoded by SEQ ID
 30 NO:338
 SEQ ID NO:344 is the predicted amino acid sequence encoded by SEQ ID

NO:339

SEQ ID NO:345 is the predicted amino acid sequence encoded by SEQ ID
NO:340

SEQ ID NO:346 is the predicted amino acid sequence encoded by SEQ ID

5 NO:341

The WT1 C sequence represents a polynucleotide having the coding regions of TR2, TR3 and TR4.

10 The WT1 TR-1 synthetic sequence represents a polynucleotide in which alternative codons for proline were substituted for the native codons, producing a polynucleotide capable of expressing WT1 TR-1 in E. coli.

EXAMPLE 13

15 EVALUATION OF THE SYSTEMIC HISTOPATHOLOGICAL AND TOXICOLOGICAL EFFECTS OF
WT1 IMMUNIZATION IN MICE

The purpose of this example is to analyze the immunogenicity and potential systemic histopathological and toxicological effects of WT1 protein immunization in a multiple dose titration in mice.

20 The experimental design for immunization of mice with WT1 protein is outlined in Table L.

Table L
Experimental Design of WT1 Immunization in Mice

Histology Group	Corixa Group	Treatment Description	Dose Level	Total No. (Females)
1	0	No treatment	0	4
2	1.1	MPL-SE (adjuvants alone), 6x, 1 week apart	10ug	4
3	1.2	MPL-SE, 3x, 2 weeks apart	10ug	4

4	2.1	Ra12-WT1 + MPL-SE, 6x	25ug	4
5	2.2	Ra12-WT1 + MPL-SE, 3x	25ug	4
6	3.1	Ra12-WT1 + MPL-SE, 6x	100ug	4
7	3.2	Ra12-WT1 + MPL-SE, 3x	100ug	4
8	4.1	Ra12-WT1 + MPL-SE, 6x	1000u g	4
9	4.2	Ra12-WT1 + MPL-SE, 3x	1000u g	4

Vaccination to WT1 protein using MPL-SE as adjuvant, in a multiple dose

- titration study (doses ranging from 25 μ g, 100 μ g to 1000 μ g WT1 protein) in female C57/B6 mice elicited a strong WT1-specific antibody response (Figure 19) and cellular T-cell responses (Figure 20).

- No systemic histopathological or toxicological effects of immunization with WT1 protein was observed. No histological evidence for toxicity was seen in the following tissues: adrenal gland, brain, cecum, colon, duodenum, eye, femur and marrow, gall bladder, heart, ileum, jejunum, kidney, larynx, lacrimal gland, liver, lung, lymph node, muscle, esophagus, ovary, pancreas, parathyroid, salivary gland, sternum and marrow, spleen, stomach, thymus, trachea, thyroid, urinary bladder and uterus.

- Special emphasis was put on evaluation of potential hematopoietic toxicity. The myeloid/erythroid ratio in sternum and femur marrow was normal. All evaluable blood cell counts and blood chemistry (BUN, creatinine, bilirubin, albumin, globulin) were within the normal range (Table LI).

- Given that existent immunity to WT1 is present in some patients with leukemia and that vaccination to WT1 protein can elicit WT1 specific Ab and cellular T-cell responses in mice without toxicity to normal tissues, these experiments validate WT1 as a tumor/leukemia vaccine.

Table LI
Clinical Chemistry and Hematology Analysis

Table LI: WT1 Dose Titration Study
Clinical Chemistry and Hematology Analysis

Animal #	K/uL WBC	M/uL RBC	g/dl Hg.	% HCT	fL MCV	pg MCH	% MCHC
Normal	5.4-16.0	6.7-12.5	10.2-16.6	32-54	31-82	9.2-20.8	22.0-35.5
Group 1							
1 (0)	5.6	8.41	12.8	43.5	53	15.2	29.4
2 (0)	5.5	9.12	13.4	47.5	53	14.7	28.2
3 (0)	7.5	9.22	13.5	48	54	14.7	28.1
4 (0)	3.9	9.27	13.6	46	52	14.7	29.6
Mean	5.6	9.0	13.3	46.3	53.0	14.8	28.8
STD	1.5	0.4	0.4	2.0	0.8	0.3	0.8
Group 2							
5 (1.6)	6.6	9	13.1	46	54	14.5	28.5
6 (1.6)	5.2	8.58	12.6	44	53	14.7	28.6
7 (1.7)	7.8	9.21	13.6	46	53	14.7	29.6
8 (1.8)	6.3	NA	NA	41	NA	NA	NA
Mean	6.5	8.9	13.1	44.3	53.3	14.6	28.9
STD	1.1	0.3	0.5	2.4	0.6	0.1	0.6
Group 3							
9 (2.5)	8.3	9.16	13.6	50.3	55	14.9	27.1
10 (2.6)	5	8.78	13	44.2	50	14.8	29.3
11 (2.7)	4	8.94	13.2	48.3	54	14.7	27.3
12 (2.8)	8.2	NA	NA	41	NA	NA	NA
Mean	6.4	9.0	13.3	46.0	53.0	14.8	27.9
STD	2.2	0.2	0.3	4.2	2.6	0.1	1.2
Group 4							
13 (3.5)	6.1	8.82	13.1	46	54	14.9	28.5
14 (3.6)	6.1	8.64	12.9	46	54	15	28
15 (3.7)	9.3	8.93	13.2	48	55	14.8	27.5
16 (3.8)	4.8	8.19	12.6	44	55	15.3	28.6
Mean	6.6	8.6	13.0	46.0	54.5	15.0	28.2
STD	1.9	0.3	0.3	1.6	0.6	0.2	0.5
Group 5							
17 (4.5)	3.1	8.48	12.6	46	54	14.9	27.5
18 (4.6)	5.7	9.12	13.7	48	54	15	28.5
19 (4.7)	5.3	8.58	13	44.5	55	15.2	29.2
20 (4.8)	5.3	NA	NA	40	NA	NA	NA
Mean	4.9	8.7	13.1	44.6	54.3	15.0	28.4

Table LI: WT1 Dose Titration Study
Clinical Chemistry and Hematology Analysis

Animal #	K/uL WBC	M/uL RBC	g/dl Hg	% HCT	fL MCV	pg MCH	% MCHC
Normal	5.4-16.0	6.7-12.5	10.2-16.6	32-54	31-62	9.2-20.8	22.0-35.5
STD	1.2	0.3	0.6	3.4	0.6	0.2	0.9
Group 6							
21 (1.1)	3.5	9.36	13.5	37.6	40	14.4	35.9
22 (1.2)	6.9	8.93	13.6	37.3	42	15.3	36.6
23 (1.3)	3.6	8.3	12.5	35.3	43	15.1	35.5
24 (1.4)	NA	NA	NA	NA	NA	NA	NA
Mean	4.7	8.9	13.2	36.7	41.7	14.9	36.0
STD	1.9	0.5	0.6	1.3	1.5	0.5	0.6
Group 7							
25 (2.1)	4	NA	NA	40	NA	NA	NA
26 (2.2)	7.4	9.12	13.2	38.5	42	14.5	34.3
27 (2.3)	4.5	8.19	12.1	34.5	42	14.8	35.1
28 (2.4)	5.8	8.25	12.3	34.1	41	14.9	36.1
Mean	5.4	8.5	12.5	36.8	41.7	14.7	35.2
STD	1.5	0.5	0.6	2.9	0.6	0.2	0.9
Group 8							
29 (3.1)	5.1	8.53	12.6	34.9	41	14.7	36
30 (3.2)	7.6	8.42	13	36.1	43	15.4	35.9
31 (3.3)	3.4	8.45	12.6	34.9	41	14.9	36.1
32 (3.4)	6.1	8.11	12.3	34.8	43	15.2	35.5
Mean	5.6	8.4	12.6	35.2	42.0	15.1	35.9
STD	1.8	0.2	0.3	0.6	1.2	0.3	0.3
Group 9							
33 (4.1)	NA	NA	NA	NA	NA	NA	NA
34 (4.2)	4.5	8.63	12.8	36.2	42	14.8	35.2
35 (4.3)	3.9	8.85	13	36.6	41	14.7	35.6
36 (4.4)	4.7	8.14	12.3	33.8	42	15.1	36.3
Mean	4.4	8.5	12.7	35.5	41.7	14.9	35.7
STD	0.4	0.4	0.4	1.5	0.6	0.2	0.6

Table LI (cont'd): WT1 Dose Titration Study
Clinical Chemistry and Hematology Analysis

Animal #	yes/no	K/uL Pit. clump Platelets	Abs. Baso	Abs. Eos	Abs. Bands	Abs. Polys	Abs. Lymph	Abs. Mono
Normal	no	150-1500	0.0-0.15	0.0-0.51	0.0-0.32	8.0-42.9	8.0-18.0	0.0-1.5
Group 1			K/uL	K/uL	K/uL	K/uL	K/uL	K/uL
1 (0)	yes	726	0	56	0	336	5208	0
2 (0)	no	860	0	0	0	55	5445	0
3 (0)	no	875	0	375	0	525	6525	75
4 (0)	yes	902	0	0	0	156	3744	0
Mean		840.8	0.0	107.8	0.0	268.0	5230.5	18.8
STD		78.4	0.0	180.1	0.0	207.0	1144.8	37.5
Group 2								
5 (1.5)	no	1193	0	132	0	792	5214	462
6 (1.6)	no	1166	0	52	0	624	4472	52
7 (1.7)	no	1087	0	234	0	1170	6396	0
8 (1.8)	yes	NA	0	126	0	126	5922	126
Mean		1148.7	0.0	136.0	0.0	678.0	5501.0	160.0
STD		55.1	0.0	74.8	0.0	433.1	840.5	207.9
Group 3								
9 (2.5)	no	705	0	166	0	664	7387	83
10 (2.6)	no	1140	0	150	0	500	4350	0
11 (2.7)	no	952	0	120	0	680	3200	0
12 (2.8)	yes	NA	0	164	0	656	7216	164
Mean		932.3	0.0	150.0	0.0	625.0	5538.3	61.8
STD		218.2	0.0	21.2	0.0	83.9	2090.6	78.6
Group 4								
13 (3.6)	no	785	0	488	0	732	4636	244
14 (3.8)	yes	973	0	0	0	488	5307	305
15 (3.7)	yes	939	0	465	0	558	7812	465
16 (3.8)	yes	1622	0	192	0	480	4080	48
Mean		1079.8	0.0	286.3	0.0	564.5	5458.8	265.5
STD		370.6	0.0	233.4	0.0	117.0	1647.1	172.4
Group 5								
17 (4.5)	no	892	0	31	0	620	2449	0
18 (4.6)	yes	966	57	114	0	855	4674	0
19 (4.7)	yes	883	0	53	0	742	4452	53
20 (4.8)	yes	NA	0	106	0	53	5141	0
Mean		913.7	14.3	76.0	0.0	567.5	4179.0	13.3
STD		45.5	28.5	40.4	0.0	356.2	1188.5	26.5

Table LI (cont'd): WT1 Dose Titration Study
Clinical Chemistry and Hematology Analysis

Animal #	yes/no	K/uL	Abs.	Abs.	Abs.	Abs.	Abs.	Abs.
Plt. clump		Platelets	Baso	Eos	Bands	Polys	Lymph	Mono
Normal	no	150-1500	0.0-0.15	0.0-0.51	0.0-0.32	8.0-42.9	8.0-18.0	0.0-1.5
Group 6								
21 (1.1)	yes	784	0	35	0	385	2870	210
22 (1.2)	yes	806	0	69	0	207	6496	138
23 (1.3)	yes	790	0	180	0	396	2988	36
24 (1.4)	NA	NA	NA	NA	NA	NA	NA	NA
Mean		793.3	0.0	94.7	0.0	329.3	4114.7	128.0
STD		11.4	0.0	75.8	0.0	106.1	2054.5	87.4
Group 7								
25 (2.1)	yes	NA	0	80	0	200	3720	0
26 (2.2)	yes	753	0	0	0	518	6734	148
27 (2.3)	yes	725	0	90	0	225	4140	45
28 (2.4)	yes	792	0	232	0	754	4814	0
Mean		756.7	0.0	100.5	0.0	424.3	4852.0	48.3
STD		33.7	0.0	96.5	0.0	263.0	1333.1	69.8
Group 8								
29 (3.1)	yes	784	0	153	0	561	4233	153
30 (3.2)	yes	512	0	152	0	304	6992	152
31 (3.3)	yes	701	0	0	0	238	3094	68
32 (3.4)	yes	631	0	305	0	305	5368	122
Mean		657.0	0.0	152.5	0.0	352.0	4921.8	123.8
STD		115.1	0.0	124.5	0.0	142.8	1663.3	39.9
Group 9								
33 (4.1)	NA	NA	NA	NA	NA	NA	NA	NA
34 (4.2)	yes	724	0	125	0	540	3780	45
35 (4.3)	yes	758	0	117	0	429	3315	39
36 (4.4)	yes	808	0	47	0	329	4089	235
Mean		763.3	0.0	96.3	0.0	432.7	3728.0	106.3
STD		42.3	0.0	42.9	0.0	105.5	389.6	111.5

Table LI (cont'd): WT1 Dose Titration Study
Clinical Chemistry and Hematology Analysis

Animal #	mg/dl BUN	mg/dl Creatinine	g/dl T. protein	g/dl Albumin	g/dl Globulin	mg/dl T. Bilirubin
Normal	13.9-28.3	0.3-1.0	4.0-8.6	2.5-4.8	1.5-3.8	0.10-0.90
Group 1						
1 (0)	NA	NA	NA	NA	NA	NA
2 (0)	28	0.5	4.9	3.7	1.2	0.3
3 (0)	25	0.5	4.9	3.8	1.1	0.2
4 (0)	27	0.5	4.7	3.7	1	0.2
Mean	26.7	0.5	4.8	3.7	1.1	0.2
STD	1.5	0.0	0.1	0.1	0.1	0.1
Group 2						
5 (1.5)	34	0.5	4.6	3.6	1	0.2
6 (1.6)	31	0.4	4.6	3.3	1.3	0.2
7 (1.7)	34	0.6	4.9	4	0.9	0.3
8 (1.8)	NA	NA	NA	NA	NA	NA
Mean	33.0	0.5	4.7	3.6	1.1	0.2
STD	1.7	0.1	0.2	0.4	0.2	0.1
Group 3						
9 (2.5)	NA	NA	NA	NA	NA	NA
10 (2.6)	33	0.5	4.6	3.6	1	0.3
11 (2.7)	NA	NA	NA	NA	NA	NA
12 (2.8)	31	0.5	4.8	3.7	1.1	0.2
Mean	32.0	0.5	4.7	3.7	1.1	0.3
STD	1.4	0.0	0.1	0.1	0.1	0.1
Group 4						
13 (3.5)	32	0.7	4.6	3.4	1.2	0.2
14 (3.6)	34	0.4	4.8	3.8	1	0.2
15 (3.7)	30	0.4	4.7	3.4	1.3	0.2
16 (3.8)	24	0.3	5.1	3.8	1.3	0.2
Mean	30.0	0.5	4.8	3.6	1.2	0.2
STD	4.3	0.2	0.2	0.2	0.1	0.0
Group 5						
17 (4.5)	22	0.4	4.6	3.3	1.3	0.2
18 (4.6)	31	0.5	4.9	3.7	1.2	0.2
19 (4.7)	23	0.6	4.8	3.6	1.2	0.2
20 (4.8)	28	0.5	4.5	3.4	1.1	0.2
Mean	26.0	0.5	4.7	3.5	1.2	0.2
STD	4.2	0.1	0.2	0.2	0.1	0.0

Table LI (cont'd): WT1 Dose Titration Study
Clinical Chemistry and Hematology Analysis

Animal #	Mg/dl BUN	mg/dl Creatinine T.	g/dl protein	g/dl Albumin	g/dl Globulin T.	mg/dl Bilirubin
Normal	13.9-28.3	0.3-1.0	4.0-8.6	2.5-4.8	1.5-3.8	0.10-0.90
Group 6						
21 (1.1)	28	0.3	5.1	3.4	1.7	0.2
22 (1.2)	36	0.3	5.1	3.8	1.3	0.2
23 (1.3)	32	0.4	4.9	3.5	1.4	0.1
24 (1.4)	NA	NA	NA	NA	NA	NA
Mean	32.0	0.3	5.0	3.6	1.5	0.2
STD	4.0	0.1	0.1	0.2	0.2	0.1
Group 7						
25 (2.1)	32	0.2	5	3.4	1.6	0.2
26 (2.2)	24	0.3	4.2	2.8	1.4	0.1
27 (2.3)	28	0.3	4.8	3.2	1.6	0.2
28 (2.4)	27	0.3	5	3.4	1.6	0.1
Mean	27.8	0.3	4.8	3.2	1.6	0.2
STD	3.3	0.0	0.4	0.3	0.1	0.1
Group 8						
29 (3.1)	32	0.3	4.9	3.3	1.6	0.2
30 (3.2)	NA	NA	NA	NA	NA	NA
31 (3.3)	18	0.3	4.8	3.1	1.7	0.2
32 (3.4)	26	0.2	4.2	2.9	1.3	0
Mean	25.3	0.3	4.6	3.1	1.5	0.1
STD	7.0	0.1	0.4	0.2	0.2	0.1
Group 9						
33 (4.1)	25	0.2	4.1	2.7	1.4	0.3
34 (4.2)	NA	NA	NA	NA	NA	NA
35 (4.3)	23	0.2	4.7	3.1	1.6	0.2
36 (4.4)	29	0.3	4.7	3.2	1.5	0.3
Mean	25.7	0.2	4.5	3.0	1.5	0.3
STD	3.1	0.1	0.3	0.3	0.1	0.1

Abbreviations: WBC: white blood cells; RBC: red blood cells; Hg.: hemoglobin; HCT: hematocrit; MCV: Mean corpuscular volume; MCH: mean corpuscular hemoglobin; MCHC: mean corpuscular hemoglobin concentration; Plt.: platelets; Abs.: Absolute; Baso: basophils; Eos: eosinophils; Abs. Bands: immature neutrophils; Polys: polymorphonuclear cells; Lymph: lymphocytes; Mono: monocytes; BUN: blood urea nitrogen.

EXAMPLE 14

ELICITATION OF HUMAN WT1-SPECIFIC T-CELL RESPONSES BY WHOLE GENE IN VITRO
PRIMING

5 This example demonstrates that WT1 specific T-cell responses
can be generated from the blood of normal individuals.

Dendritic cells (DC) were differentiated from monocyte cultures derived from PBMC of normal donors by growth for 4-10 days in RPMI medium containing 10% human serum, 50 ng/ml GMCSF and 30 ng/ml IL-4. Following culture, DC were infected 16 hours with recombinant WT1-expressing vaccinia
10 virus at an M.O.I. of 5, or for 3 days with recombinant WT1-expressing adenovirus at an M.O.I. of 10 (Figures 21 and 22). Vaccinia virus was inactivated by U.V. irradiation. CD8+ T-cells were isolated by positive selection using magnetic beads, and priming cultures were initiated in 96-well plates. Cultures were restimulated every 7-10 days using autologous dendritic cells
15 adeno or vaccinia infected to express WT1. Following 3-6 stimulation cycles, CD8+ lines could be identified that specifically produced interferon-gamma when stimulated with autologous-WT1-expressing dendritic cells or fibroblasts. The WT1-specific activity of these lines could be maintained following additional stimulation cycles. These lines were demonstrated to specifically
20 recognize adeno or vaccinia WT1 infected autologous dendritic cells but not adeno or vaccinia EGFP-infected autologous dendritic cells by Elispot assays (Figure 23).

EXAMPLE 15

25 FORMULATION OF RA12-WT1 FOR INJECTION: USE OF EXCIPIENTS TO STABILIZE
LYOPHILIZED PRODUCT

This example describes the formulation that allows the complete solubilization of lyophilized Ra12-WT1.

The following formulation allowed for the recombinant protein
30 Ra12-WT1 to be dissolved into an aqueous medium after being lyophilized to dryness:

Recombinant Ra12-WT1 concentration: 0.5 – 1.0 mg/ml; Buffer:
10-20 mM Ethanolamine, pH 10.0; 1.0 – 5.0 mM Cysteine; 0.05 % Tween-80
(Polysorbate-80); Sugar: 10% Trehalose (T5251, Sigma, MO) 10% Maltose
(M9171, Sigma, MO) 10% Sucrose (S7903, Sigma, MO) 10% Fructose (F2543,
5 Sigma, MO) 10% Glucose (G7528, Sigma, MO).

The lyophilized protein with the sugar excipient was found to
dissolve significantly more than without the sugar excipient. Analysis by
coomassie stained SDS-PAGE showed no signs of remaining solids in the
dissolved material.

10

EXAMPLE 16

FORMULATION OF A WT1 PROTEIN VACCINE

This example describes the induction of WT1-specific immune
responses following immunization with WT1 protein and 2 different adjuvant
15 formulations.

According to this example, WT1 protein in combination with MPL-
SE induces a strong Ab and Interferon- γ (IFN- γ) response to WT1. Described
in detail below are the methods used to induce WT1 specific immune
responses following WT1 protein immunization using MPL-SE or Enhanzyn as
20 adjuvant in C57/B6 mice.

C57BL/6 mice were immunized with 20 μ g rRa12-WT1 combined
with either MPL-SE or Enhanzyn adjuvants. One group of control mice was
immunized with rRa12-WT1 without adjuvant and one group was immunized
with saline alone. Three intramuscular (IM) immunizations were given, three
25 weeks apart. Spleens and sera were harvested 2 weeks post-final
immunization. Sera were analyzed for antibody responses by ELISA on plates
coated with Ra12-WT1 fusion, Ra12 or WT1TRX. Similar levels of IgG2a and
IgG1 antibody titers were observed in mice immunized with Ra12-WT1+MPL-
SE and Ra12-WT1+Enhanzyn. Mice immunized with rRa12-WT1 without
30 adjuvant showed lower levels of IgG2a antibodies.

CD4 responses were assessed by measuring Interferon- γ production following stimulation of splenocytes *in vitro* with rRA12-WT1, rRA12 or with WT1 peptides p6, p117 and p287. Both adjuvants improved the CD4 responses over mice immunized with rRA12-WT1 alone. Additionally, the results indicate that rRA12-WT1+MPL-SE induced a stronger CD4 response than did rRA12-WT1+Enhancyn. IFN- γ OD readings ranged from 1.4-1.6 in the mice immunized with rRA12-WT1+MPL-SE as compared to 1-1.2 in the mice immunized with rRA12-WT1+Enhancyn. Peptide responses were only observed against p117, and then only in mice immunized with rRA12-WT1+MPL-SE. Strong IFN- γ responses to the positive control, ConA, were observed in all mice. Only responses to ConA were observed in the negative control mice immunized with saline indicating that the responses were specific to rRA12-WT1.

15

EXAMPLE 17

CONSTRUCTION OF A RANDOMLY MUTATED WT1 LIBRARY

The nucleic acid sequence of human WT1 was randomly mutated using a polymerase chain reaction method in the presence of 8-oxo dGTP and dPTP (Journal of Molecular Biology 1996; 255:589-603). The complete unspliced human WT1 gene is disclosed in SEQ ID NO:380 and the corresponding protein sequence is set forth in SEQ ID NO:404. A splice variant of WT1 was used as a template for the PCR reactions and is disclosed in SEQ ID NOs:381 (DNA) and 408 (protein). Conditions were selected so that the frequency of nucleic acid alterations led to a targeted change in the amino acid sequence, usually 5-30% of the PCR product. The mutated PCR product was then amplified in the absence of the nucleotide analogues using the four normal dNTPs. This PCR product was subcloned into mammalian expression vectors and viral vectors for immunization. This library, therefore, contains a mixed population of randomly mutated WT1 clones. Several clones were selected and sequenced. The mutated WT1 variant DNA sequences are disclosed in SEQ ID NOs:377-379 and the predicted amino acid sequences of

30

the variants are set forth in SEQ ID NOs:405-407. These altered sequences, and others from the library, can be used as immunogens to induce stronger T cell responses against WT1 protein in cancer cells.

5

EXAMPLE 18

CONSTRUCTION OF WT1-LAMP FUSIONS

A tripartite fusion was constructed using the polymerase chain reaction and synthetic oligonucleotides containing the desired junctions of human lysosomal associated membrane protein-1 (LAMP-1) and a splice
10 variant of the human WT1 sequence. The splice variant of WT1 and the LAMP-1 sequence used for these fusions are disclosed in SEQ ID NOs:381 and 383. Specifically, the signal peptide of LAMP-1 (base pairs 1-87 of LAMP) was fused to the 5-prime end of the human WT1 open reading frame (1,290 base pairs in length), then the transmembrane and cytoplasmic domain of
15 LAMP-1 (base pairs 1161 to 1281 of LAMP) was fused to the 3-prime end of the WT1 sequence. The sequence of the resulting WT1-LAMP construct is set forth in SEQ ID NO:382 (DNA) and SEQ ID NO:409 (protein). The construct was designed so that when it is expressed in eukaryotic cells, the signal peptide directs the protein to the endoplasmic reticulum (ER) where the
20 localization signals in the transmembrane and cytoplasmic domain of LAMP-1 direct transport of the fusion protein to the lysosomal location where peptides are loaded on to Class II MHC molecules.

EXAMPLE 19

25 CONSTRUCTION OF WT1-UBIQUITIN FUSIONS FOR ENHANCED MHC CLASS I PRESENTATION

The human ubiquitin open reading frame (SEQ ID NO:384) was mutated such that the nucleotides encoding the last amino acid encode an alanine instead of a glycine. This mutated open reading frame was cloned in
30 frame just upstream of the first codon of a splice variant of human WT1 (SEQ ID NOs:381 and 408, DNA and protein, respectively). The G->A mutation

prevents co-translational cleavage of the nascent protein by the proteases that normally process poly-ubiquitin during translation. The DNA and predicted amino acid sequence for the resulting construct are set forth in SEQ ID NOs:385 and 410, respectively. The resulting protein demonstrated decreased cellular
5 cytotoxicity when it was expressed in human cells. Whereas it was not possible to generate stable lines expressing native WT1, cell lines expressing the fusion protein were readily obtained. The resulting protein is predicted to be targeted to the proteasome by virtue of the added ubiquitin molecule. This should result in more efficient recognition of the protein by WT1 specific CD8+ T cells.

10

EXAMPLE 20

CONSTRUCTION OF AN ADENOVIRUS VECTOR EXPRESSING HUMAN WT1

A splice variant of human WT1 (SEQ ID NO:381) was cloned into an E1 and E3 deleted adenovirus serotype 5 vector. The expression of the
15 WT1 gene is controlled by the CMV promoter mediating high levels of WT1 protein expression. Infection of human cells with this reagent leads to a high level of expression of the WT1 protein. The antigenic nature of the adenoviral proteins introduced into the host cell during and produced at low levels subsequent to infection can act to increase immune surveillance and immune
20 recognition of WT1 as an immunological target. This vector can be also used to generate immune responses against the WT1 protein when inoculated into human subjects. If these subjects are positive for WT1 expressing tumor cells the immune response could have a therapeutic or curative effect on the course of the disease.

25

EXAMPLE 21

CONSTRUCTION OF A VACCINIA VIRUS VECTOR EXPRESSING HUMAN WT1

A splice variant of the full length human WT1 gene (SEQ ID NO:381) was cloned into the thymidine kinase locus of the Western Reserve
30 strain of the vaccinia virus using the pSC11 shuttle vector. The WT1 gene is under the control of a hybrid vaccinia virus promoter that mediates gene

expression throughout the course of vaccinia virus infection. This reagent can be used to express the WT1 protein in human cells in vivo or in vitro. WT1 is a self protein that is overexpressed on some human tumor cells. Thus, immunological responses to WT1 delivered as a protein are unlikely to lead to

5 Major Histocompatibility Class I (MHC class I)-mediated recognition of WT1. However, expression of the protein in the intracellular compartment by the vaccinia virus vector will allow high level MHC class I presentation and recognition of the WT1 protein by CD8+ T cells. Expression of the WT1 protein by the vaccinia virus vector will also lead to presentation of WT1 peptides in the

10 context of MHC class II and thus to recognition by CD4+ T cells.

The uses of this invention include its use as a cancer vaccine. Immunization of human subjects bearing WT1 positive tumors could lead to a therapeutic or curative response. The expression of WT1 within the cell will lead to recognition of the protein by both CD4 and CD8 positive T cells.

15

EXAMPLE 22

GENERATION OF WT1-SPECIFIC CD8+ T-CELL CLONES USING WHOLE GENE PRIMING

Dendritic cells (DC) were differentiated from monocyte cultures derived from PBMC of normal donors by growth for 4-6 days in RPMI medium

20 containing 10% human serum, 50 ng/ml GM-CSF and 30 ng/ml IL-4. Following culture, DC were infected 16 hours with recombinant WT1-expressing vaccinia virus (described in Example 21) at a multiplicity of infection (MOI) of 5 or for 3 days with recombinant WT1-expressing adenovirus at an MOI of 10. Vaccinia virus was inactivated by U.V. irradiation. CD8+ T-cells were isolated by

25 negative depletion using magnetic beads, and priming cultures were initiated in 96-well plates. Cultures were restimulated every 7-10 days using autologous dendritic cells infected with adeno or vaccinia virus engineered to express WT1. Following 4-5 stimulation cycles, CD8+ T-cell lines could be identified that specifically produced interferon-gamma when stimulated with autologous-

30 WT1 expressing dendritic cells or fibroblasts. These lines were cloned and

demonstrated to specifically recognize WT1 transduced autologous fibroblasts but not EGFP transduced fibroblasts by Elispot assays.

The Wilms' tumor (WT1) gene participates in leukemogenesis and is overexpressed in most human leukemias as well as in several solid tumors. Previous studies in humans have demonstrated the presence of WT1 specific antibody (Ab) responses in 16/63 (25%) of AML and in 15/81 (19%) of CML patients studied. Previous studies in mice have shown that WT1 peptide based vaccines elicit WT1 specific Ab, Th and CTL responses. The use of peptides as vaccines in humans is limited by their HLA restriction and the tendency to elicit peptide specific responses and only in a minority of patients tumor specific CTL. The advantages of whole gene immunization are that several helper and CTL epitopes can be included in a single vaccine, thus not restricting the vaccine to specific HLA types. The data disclosed herein demonstrate the induction of WT1 specific immune responses using whole gene in vitro priming, and that WT1 specific CD8+ T-cell clones can be generated. Given that existent immunity to WT1 is present in some patients with leukemia and that murine and human WT1 are 96% identical at the amino acid level and vaccination to WT1 protein, DNA or peptides can elicit WT1 specific Ab, and cellular T-cell responses in mice without toxicity to normal tissues in mice, these human in vitro priming experiments provide further validation of WT1 as a tumor/leukemia vaccine. Furthermore, the ability to generate WT1 specific CD8+ T-cell clones may lead to the treatment of malignancies associated with WT1 overexpression using genetically engineered T-cells.

25

EXAMPLE 23

RECOMBINANT CONSTRUCTS FOR CLINICAL MANUFACTURING OF WT1

Five constructs were made as described in detail below, for the production of clinical grade WT1.

Design of Ra12/WT-E (SEQ ID NOs:388 (cDNA) and 391 (protein)) and WT-1 E (SEQ ID NOs:386 (cDNA) and 395 (protein)) with No His tag:

30

The WT-1 E reading frame was PCR amplified with the following primers for the non-His non fusion construct:

PDM-780 (SEQ ID NO:396) 5' gacgaagcatatgcactcctcatcaaac 3'

Tm 66°C

5 PDM-779 (SEQ ID NO:397) 5' cgcgtgaattcatcactgaatgcctctgaag 3'

Tm 63°C

The following PCR cycling conditions were used: 1 µl 10X Pfu buffer, 1 µl 10mM dNTPs, 2 µl 1 µM each oligo, 83 µl sterile water 1.5 µl Pfu DNA polymerase (Stratagene, La Jolla, CA), 50 ng DNA (pPDMRa12 WT-1 No His).

- 10 The reaction was denatured initially at 96°C for 2 minutes, followed by 40 cycles of 96°C for 20 seconds, 62°C for 15 seconds, and 72°C for 1 minute and 40 seconds. This was followed by a final extension of 72°C for 4 minutes. The PCR product was digested with NdeI and EcoRI and cloned into pPDM His (a modified pET28 vector) that had been digested with NdeI and EcoRI. The
- 15 construct was confirmed through sequence analysis and then transformed into BLR (DE3) pLys S and HMS 174 (DE3) pLys S cells. This construct – pPDM WT-1 E was then digested with NcoI and XbaI and used as the vector backbone for the NcoI and XbaI insert from pPDM Ra12 WT-1 F (see below). The construct was confirmed through sequence analysis and then transformed
- 20 into BLR (DE3) pLys S and HMS 174 (DE3) pLys S cells. Protein expression was confirmed by Coomassie stained SDS-PAGE and N-terminal protein sequence analysis.

Design of Ra12-WT-1-F (a.a. 1-281) with No His tag (SEQ ID NOs:389 (cDNA) and 393 (protein)):

- 25 The Ra12 WT-1 reading frame was PCR amplified with the following primers:

PDM-777 (SEQ ID NO:398) 5' cgataagcatatgacggccgcgtccgataac

3' Tm 66°C

PDM-779 (SEQ ID NO:399) 5' cgcgtgaattcatcactgaatgcctctgaag 3'

30 Tm 63°C

- The following PCR cycling conditions were used: 1 μ l 10X Pfu buffer, 1 μ l 10mM dNTPs, 2 μ l 1 μ M each oligo, 83 μ l sterile water 1.5 μ l Pfu DNA polymerase (Stratagene, La Jolla, CA), 50 ng DNA (pPDMRa12 WT-1 No His). The reaction was denatured initially at 96°C for 2 minutes, followed by 40
- 5 cycles of 96°C for 20 seconds, 58°C for 15 seconds, and 72°C for 3 minutes. This was followed by a final extension of 72°C for 4 minutes. The PCR product was digested with NdeI and cloned into pPDM His that had been digested with NdeI and Eco72I. The sequence was confirmed through sequence analysis and then transformed into BLR (DE3) pLys S and HMS 174 (DE3) pLysS cells.
- 10 Protein expression was confirmed by Coomassie stained SDS-PAGE and N-terminal protein sequence analysis.

Design of Ra12-WT-1 with No His tag (SEQ ID NOs:390 (cDNA) and 392 (protein)):

- The Ra12 WT-1 reading frame was PCR amplified with the
- 15 following primers:
- PDM-777 (SEQ ID NO:400) 5' cgataagcatatgacggccgcgtccgataac
3' Tm 66°C
- PDM-778 (SEQ ID NO:401) 5' gtctgcagcgccgcctcaaagcgcagc 3'
Tm 7°C

- 20 The following PCR cycling conditions were used: 1 μ l 10X Pfu buffer, 1 μ l 10mM dNTPs, 2 μ l 1 μ M each oligo, 83 μ l sterile water 1.5 μ l Pfu DNA polymerase (Stratagene, La Jolla, CA), 50 ng DNA (pPDMRa12 WT-1 No His). The reaction was denatured initially at 96°C for 2 minutes, followed by 40
- 25 cycles of 96°C for 20 seconds, 68°C for 15 seconds, and 72°C for 2 minutes and 30 seconds. This was followed by a final extension of 72°C for 4 minutes. The PCR product was digested with NotI and NdeI and cloned into pPDM His that had been digested with NdeI and NotI. The sequence was confirmed through sequence analysis and then transformed into BLR (DE3) pLys S and HMS 174 (DE3) pLysS cells. Protein expression was confirmed by Coomassie
- 30 stained SDS-PAGE and N-terminal protein sequence analysis.

Design of WT-1 C (a.a. 69-430) in *E. coli* without His tag (SEQ ID NOs:387 (cDNA) and 394 (protein)):

The WT-1 C reading frame was PCR amplified with the following primers:

5 PDM-780 (SEQ ID NO:402) 5' gacgaaagcatatgcactcttcatcaaac 3'
Tm 6°C

PDM-778 (SEQ ID NO:403) 5' gtctgcagcgccgctcaaagcgccagc 3'
Tm 7°C

The following PCR cycling conditions were used: 1 µl 10X Pfu buffer, 1 µl 10mM dNTPs, 2 µl 1 µM each oligo, 83 µl sterile water 1.5 µl Pfu DNA polymerase (Stratagene, La Jolla, CA), 50 ng DNA (pPDMRa12 WT-1 No His). The reaction was denatured initially at 96°C for 2 minutes, followed by 40 cycles of 96°C for 20 seconds, 62°C for 15 seconds, and 72°C for 2 minutes. This was followed by a final extension of 72°C for 4 minutes. The PCR product was digested with NdeI and cloned into pPDM His that had been digested with NdeI and Eco72I. The sequence was confirmed through sequence analysis and then transformed into BLR (DE3) pLys S and HMS 174 (DE3) pLys S cells. Protein expression was confirmed by Coomassie stained SDS-PAGE and N-terminal protein sequence analysis.

20

EXAMPLE 24

GENERATION OF WT1-SPECIFIC CD8⁺ T CELL CLONES USING WHOLE GENE PRIMING
AND IDENTIFICATION OF AN HLA-A2-RESTRICTED WT1 EPITOPE

In this example, Adeno and Vaccinia virus delivery vehicles were used to generate WT1-specific T cell lines. A T cell clone from the line was shown to be specific for WT1 and further, the epitope recognized by this clone was identified.

Dendritic cells (DC) were differentiated from monocyte cultures derived from PBMC of normal donors by growth for 4-6 days in RPMI medium containing 10% human serum, 50 ng/ml GM-CSF and 30 ng/ml IL-4. Following culture, DC were infected 16 hours with recombinant WT1-expressing vaccinia

virus at a multiplicity of infection (MOI) of 5 or for 2-3 days with recombinant WT1-expressing adeno virus at an MOI of 3-10. Vaccinia virus was inactivated by U.V. irradiation. CD8+ T-cells were isolated by negative depletion using antibodies to CD4, CD14, CD16, CD19 and CD56+ cells, followed by magnetic
5 beads specific for the Fc portion of these Abs.

Priming cultures were initiated in 96-well plates. Cultures were restimulated every 7-14 days using autologous dendritic cells infected with adeno or vaccinia virus engineered to express WT1. Following 4-5 stimulation cycles, CD8+ T cell lines could be identified that specifically produced
10 interferon- γ (IFN- γ) when stimulated with autologous-WT1 expressing dendritic cells or fibroblasts. These lines were cloned and demonstrated to specifically recognize WT1 transduced autologous fibroblasts but not control transduced fibroblasts by Elispot assays.

To further analyze HLA restriction of these WT1 specific CD8+ T-
15 cell clones, fibroblasts derived from an additional donor (D475), sharing only the HLA-A2 allele with the donor (D349) from which the T-cell clone was established, were transduced with WT1. ELISPOT analysis demonstrated recognition of these D475 target cells by the T-cell clone. To further demonstrate HLA A2 restriction and demonstrate that this epitope is expressed
20 by tumor cells "naturally" overexpressing WT1 (as part of their malignant transformation), the leukemia cell line K562 was tested. K562 was transduced with the HLA A2 molecule, and HLA-A2 negative K562 cells were used as controls for nonspecific IFN- γ release. ELISPOT analysis demonstrated that the T cells recognized the A2 positive K562 cell line, but not the A2 negative
25 K562 cells. Further proof of specificity and HLA-A2 restriction of the recognition was documented by HLA-A2 antibody blocking experiments.

To further define the WT1 epitope, 4 truncated WT1 retroviral constructs were generated. Donor 475 fibroblasts were then transduced with these constructs. ELISPOT assays demonstrated recognition of D475
30 fibroblasts transduced with the WT1 Tr1 construct (aa2-aa92), thus demonstrating that the WT1 epitope is localized within the first 91 N-terminal

amino acids of the WT1 protein. To fine map the epitope, 15mer peptides of the WT1 protein, overlapping by 11 amino acids, were synthesized. The WT1 specific T-cell clone recognized two overlapping 15mer peptides, peptide 9 (QWAPVLDFAAPPGASA) (SEQ ID NO: 412) and peptide 10
5 (VLDFAPPGASAYGSL) (SEQ ID NO: 413). To further characterize the minimal epitope recognized, shared 9mer and 10mer peptides of the 15mers (5 total) were used to analyse the specificity of the clone. The clone specifically recognized the 9mer, VLDFAPPGA (SEQ ID NO:241), and the 10mer, VLDFAPPGAS (SEQ ID NO:411).

10

EXAMPLE 25

CLONING AND SEQUENCING OF TCR ALPHA AND BETA CHAINS DERIVED FROM A CD8 T CELL SPECIFIC FOR WT1

T cell receptor (TCR) alpha and beta chains from CD8+ T cell
15 clones specific for WT1 are cloned. Sequence analysis is carried to demonstrate the family origin of the the alpha and beta chains of the TCR. Additionally, unique diversity and joining segments (contributing to the specificity of the response) are identified.

Total mRNA from 2×10^6 cells from a WT1 specific CD8+ T cell
20 clone is isolated using Trizol reagent and cDNA is synthesized using Ready-to-go kits (Pharmacia). To determine V α and V β sequences in a clone, a panel of V α and V β subtype specific primers are synthesized (based on primer sequences generated by Clontech, Palo Alto, CA) and used in RT-PCR reactions with cDNA generated from each clone. The RT-PCR reactions
25 demonstrate which V β and V α sequence is expressed by each clone.

To clone the full-length TCR alpha and beta chains from a clone, primers are designed that span the initiator and terminator-coding TCR nucleotides. Standard 35 cycle RT-PCR reactions are established using cDNA synthesized from the CTL clone and the above primers using the proofreading
30 thermostable polymerase PWO (Roche, Basel, Switzerland). The resultant specific bands (~850 bp for alpha and ~950 for beta) are ligated into the PCR

- blunt vector (Invitrogen, Carlsbad, CA) and transformed into *E.coli*. *E.coli* transformed with plasmids containing full-length alpha and beta chains are identified, and large scale preparations of the corresponding plasmids are generated. Plasmids containing full-length TCR alpha and beta chains are then
- 5 sequenced using standard methods. The diversity-joining (DJ) region that contributes to the specificity of the TCR is thus determined.

EXAMPLE 26

- WT1 SPECIFIC CD8+ T-CELL CLONE Lyses WT1-EXPRESSING LEUKEMIC BLASTS
- 10 The CD8+ T cell clone initially disclosed in Example 24 that recognizes peptide sequence VLDFAAPPGA (human WT1 residues 37-45; SEQ ID NO:241) was further tested for the ability to kill (lyse) WT1 expressing leukemia target cells in an HLA A2 restricted fashion. K562 target cells transduced with the HLA A2 molecule, GFP, A2Kb, or untransduced, were
- 15 used in a standard 4.5 hour ⁵¹Chromium release assay with effector to target cell (E:T) ratios of 25:1 and 5:1. At an E:T ratio of 25:1, the CD8+ T-cell clone lysed the K562/A2 and K562/A2Kb cells (40% and 49% specific lysis, respectively) while the control GFP transduced and the K562 cells were not lysed. At an E:T of 5:1, specific lysis of the K562/A2 and K562/A2Kb cells was
- 20 21% and 24%, respectively. Thus, this CD8+ T cell clone recognizes and lyses leukemic cells expressing WT1 in an HLA-A2-restricted fashion. The ability to generate WT1 specific CD8+ T-cell clones has utility in the treatment of malignancies associated with WT1 overexpression using genetically engineered T-cells.

25

EXAMPLE 27

CONSTRUCTION OF HLA-A2-PEPTIDE-MHC TETRAMERIC COMPLEXES

- This example describes the cloning and expression of soluble HLA-A2 in insect cells, and the purification and assembly of HLA-A2 into
- 30 fluorescent, multivalent peptide-MHC tetramer complexes for the detection and isolation of antigen-specific CD8 T cells.

This system is similar to that developed and described by Altman, et al. (Altman, J., et al., Science, 1996 274(5284):94-6) in that soluble HLA-A2 was singly biotinylated at a birA recognition sequence and was subsequently assembled into multimers on a phycoerythrin-conjugated streptavidin scaffolding. The materials described herein differ in that the HLA-A2 was expressed in a glycosylated, soluble form from insect cells and the heterodimer was purified using an anti-human class I MHC antibody affinity column.

The HLA-A2 heavy chain gene, appended with the birA biotinylation sequence, and the human beta-2-microglobulin gene were cloned into the baculovirus expression vector pFASTBAC-dual. Upon infection of insect cells the genes were concomitantly transcribed from divergent promoters and fully assembled, glycosylated soluble HLA-A2 heterodimer was secreted into the growth medium. The infected insect cells were cultured in cell factories for 4 days at 21°C before the supernatants were harvested. HLA-A2 production was monitored by a capture ELISA employing the W6/32 and biotinylated B9.12.1 antibodies. HLA-A2 was purified from the culture supernatant to >90% purity in one step by affinity chromatography using 2 anti-human class I MHC monoclonal antibodies linked to Sepharose beads. The antibodies used were PA2.1 and W6/32. Purified HLA-A2 was singly biotinylated on the birA recognition sequence on the C-terminus of the heavy chain using the commercially available birA enzyme. The efficiency of biotinylation was evaluated essentially as described (Crawford et al (1998) Immunity June ;8(6):675-82.), and the material was further purified by size exclusion chromatography (SEC). Phycoerythrin-conjugated streptavidin was saturated with bio-HLA-A2 and the multivalent staining reagent was purified from free HLA-A2 by SEC. HLA-A2 tetramer was incubated for 48 hours at room temperature with a 10-fold molar excess of Her-2/neu E75 peptide or Influenza matrix M1 peptide before the specific T cell clones were stained at 4°C for 30 minutes in the presence of peptide loaded tetramer and anti-CD8 antibody. Results indicated that the tetramers incubated in the presence of molar excess of the M1 58-66 M1 influenza peptide specifically stained an

influenza-specific T cell clone and the tetramers incubated with an excess of the Her-2/neu E75 peptide specifically stained the Her-2/new specific T cell clone.

5

EXAMPLE 28

DETECTION OF WT1 SPECIFIC T-CELLS USING WT1 MHC-PEPTIDE TETRAMERS

HLA-A2 tetramers described in Example 27 were incubated with a molar excess of the WT1 p37-45 peptide (VLDFAPPGA) (human WT1 residues 37-45; SEQ ID NO:241) previously shown in Example 24 to be restricted by HLA-A2. This tetramer was used to stain the WT1-specific CD8+ T cell clone described in Example 24. This clone was shown to specifically recognize the p37-45 epitope. When the tetramers were incubated with an excess of p37-45 peptide, they specifically stained the CD8+ T cell clone while those tetramers incubated with an excess of irrelevant HLA-A2 peptides (Her2/neu, WT1p38-46, WT1p39-47), the tetramers did not stain the CD8+ T cell clone. Thus, the WT1p37-45-specific CD8+ T cell clone is specifically recognized by the HLA-A2-p37-45 peptide MHC tetramer.

A WT1-specific T cell line generated as described in Example 24 was then stained with the HLA-A2-p37-45, irrelevant Her2/neu or WT1p37-46 tetramers. The HLA-A2-p37-45 tetramers stained 1% of the total population of this WT1-specific T cell line and 7% of the gated CD8+ population while the control HLA-A2-p37-46 tetramer stained at the same background levels as the control HLA-A2-Her2/neu tetramers.

These results indicate that MHC-peptide tetramers are a highly sensitive and specific tool for detecting WT1 specific immune responses. The peptide-MHC tetramers can be used for early detection of WT1 associated malignancies, monitoring WT1-specific responses,, and for monitoring minimal residual disease. Detection of WT1 specific T-cells by tetramer staining is also a useful tool to identify groups within a patient population suffering from a WT1 associated disease at a higher risk for relapse or disease progression.

EXAMPLE 29

GENERATION OF A WT1-SPECIFIC CD8⁺ T CELL LINE FROM AN HLA-A24-POSITIVE
DONOR USING WHOLE GENE PRIMING

In this example, Adeno and Vaccinia virus delivery vehicles were
5 used to generate WT1-specific T cell lines from an HLA-A24 positive donor.
This T cell line was shown to be MHC class I restricted. These experiments
further confirm the immunogenicity of the WT1 protein and support its use as a
target for vaccine and/or other immunotherapeutic approaches.

Dendritic cells (DC) were differentiated from monocyte cultures
10 derived from PBMC of a normal HLA-A24-positive donor by growth for 4-6 days
in RPMI medium containing 10% human serum, 50 ng/ml GM-CSF and 30
ng/ml IL-4. Following culture, DC were infected 16 hours with recombinant
WT1-expressing vaccinia virus at a multiplicity of infection (MOI) of 5 or for 2-3
days with recombinant WT1-expressing adeno virus at an MOI of 3-10.
15 Vaccinia virus was inactivated by U.V. irradiation. CD8⁺ T-cells were isolated
by negative depletion using antibodies to CD4, CD14, CD16, CD19 and CD56+
cells, followed by magnetic beads specific for the Fc portion of these Abs.

Priming cultures were initiated in 96-well plates. Cultures were
restimulated every 7-14 days using autologous dendritic cells infected with
20 adeno or vaccinia virus engineered to express WT1. Following 4-5 stimulation
cycles, CD8⁺ T cell lines could be identified that specifically produced
interferon- γ (IFN- γ) when stimulated with autologous-WT1 expressing dendritic
cells or fibroblasts. These lines were cloned and shown by Elispot assays to
specifically recognize WT1 transduced autologous fibroblasts but not control
25 transduced fibroblasts in an MHC class I-restricted manner.

These experiments show that the WT1 protein can be used to
generate a T cell response and thus, further confirm the immunogenicity of the
WT1 antigen and support its use as a target for vaccine and other
immunotherapeutic approaches.

30

EXAMPLE 30

IDENTIFICATION OF HLA-A2 HIGH AFFINITY WT1 EPITOPES

This experiment describes the *in silico* identification of WT1 epitopes predicted to bind to HLA-A2 with higher affinity than naturally processed epitopes. The epitopes identified herein have utility in vaccine and/or immunotherapeutic strategies for the treatment of cancers associated with WT1 expression.

Peptide analogs of the naturally processed HLA A2 restricted WT1 epitope p37-45 (VLDFAPPGA; human WT1 residues 37-45; SEQ ID NO:241; previously shown in Example 24 to be restricted by HLA-A2) with motifs for binding to HLA-A2.1 with higher affinity than the naturally processed peptide were constructed as described in further detail below.

A peptide motif searching program based on algorithms developed by Rammensee, et al (Hans-Georg Rammensee, Jutta Bachmann, Niels Nikolaus Emmerich, Oskar Alexander Bachor, Stefan Stevanovic: SYFPEITHI: database for MHC ligands and peptide motifs. Immunogenetics (1999) 50: 213-219) and by Parker, et al (Parker, K. C., M. A. Bednarek, and J. E. Coligan. 1994. Scheme for ranking potential HLA-A2 binding peptides based on independent binding of individual peptide side-chains. J. Immunol. 152:163.) was used to identify analogs of the WT1 p37-45 peptide epitope that are predicted to bind to HLA-A2 with higher affinity than the natural p37-45 peptide. The peptides shown in Table LII have predicted peptide binding scores equal to or greater than the naturally processed p37-45 peptide. The binding score is derived from a predicted half-time of dissociation to the HLA-A2 class I molecule. The analysis is based on coefficient tables deduced from the published literature by Dr. Kenneth Parker kparker@atlas.niaid.nih.gov, NIAID, NIH.

Table III
p37-45 Peptide Analogs

Position Modified	Sequence	Theoretical Binding Score	SEQ ID NO:
Wild Type	VLDFAPPGA	3.378	241
P1	ILDFAPPGA	3.378	414
P1	LLDFAPPGA	3.378	415
P1	FLDFAPPGA	9.141	416
P1	KLDFAPPGA	6.955	417
P1	MLDFAPPGA	3.378	418
P1	YLDFAPPGA	9.141	419
P2	VMDFAAPGA	2.44	420
P4	VLDEAPPGA	13.85	421
P4	VLDKAPPGA	3.378	422
P6	VLDFAVPGA	7.77	423
P8	VLDFAPPKA	3.378	424
P9	VLDFAPPGV	47.3	425
P9	VLDFAPPGI	14.53	426
P1 and P4	FLDEAPPGA	37.48	427
P1 and P4	KLDEAPPGA	28.52	428
P1 and P4	YLDEAPPGA	37.48	429
P1 and P4	FLDKAPPGA	9.141	430
P1 and P4	KLDKAPPGA	6.955	431
P1 and P4	YLDKAPPGA	9.141	432
P1 and P9	FLDFAPPGV	128	433
P1 and P9	KLDFAPPGV	97.37	434
P1 and P9	YLDFAPPGV	128	435
P1 and P9	FLDFAPPGI	39.31	436
P1 and P9	KLDFAPPGI	29.91	437

Position Modified	Sequence	Theoretical Binding Score	SEQ ID NO:
P1 and P9	YLDFAPPGL	39.31	438
P1, P4 and P9	FLDEAPPGV	524.7	439
P1, P4 and P9	KLDEAPPGV	399.2	440
P1, P4 and P9	YLDEAPPGV	524.7	441
P1, P4 and P9	FLDEAPPGL	161.2	442
P1, P4 and P9	KLDEAPPGL	122.6	443
P1, P4 and P9	YLDEAPPGL	161.2	444

- In a separate analysis, computer modeling was used to identify peptide epitope analogs of the p37-45 WT1 epitope. The coordinates of the HLA-A2 native structure were downloaded from the Brookhaven protein database (pdb I.D.: 3HLA) (L. L. Walsh, "Annotated PDB File Listing", Protein Science 1:5, Diskette Appendix (1992). This file was used as a template for manipulations with the SwissModel (Peitsch MC (1996) ProMod and Swiss-Model: Internet-based tools for automated comparative protein modeling. *Biochem. Soc. Trans.* 24:274-279.) program available through the Expasy web site (Appel R.D., Bairoch A., Hochstrasser D.F. A new generation of information retrieval tools for biologists: the example of the ExPASy WWW server. *Trends Biochem. Sci.* 19:258-260(1994). The peptide bound to the protein was mutated manually to yield the bound WT p37-45 peptide. The new structure was submitted for three rounds of energy minimization with the GROMOS96 implementation of the Swiss-PdbViewer; two energy minimizations were performed on the whole structure, followed by one round with unfavorable residues selected. A final evaluation showed an overall favorable energy state for the model. Ramachandran plotting indicated that only one non-glycyl residue is far in disallowed regions. Peptides identified using the modeling method described herein are set forth in Table LIII below.

Table LIII
p37-45 Peptide Analogs Identified by Computer Modeling

Position Modified	Sequence	SEQ ID NO:
Wild Type	VLDFAPPGA	241
P6	VLDFAGPGA	445
P6	VLDFATPGA	446
P6 and P9	VLDFATPGV	447
P6 and P9	VLDFATPGL	448
P6 and P9	VLDFATPGS	449
P6 and P9	VLDFATPGA	450

- 5 Several peptides identified using the two methods described above were then tested for the ability to be recognized by the p37-45 specific CTL clone (see Example 24). ELISPOT analysis showed that peptides p37-1 (SEQ ID NO:426) and model-1 (SEQ ID NO:445) were recognized by the p37-45 CTL clone. These results suggest that these 2 peptide analogs are
- 10 predicted to bind to HLA-A2 with higher affinity than the naturally processed epitope and still be recognized by a native T cell receptor.

- Thus, this experiment describes the *in silico* identification of WT1 epitopes predicted to bind to HLA-A2 with higher affinity than naturally processed epitopes. Two of the epitopes identified were tested and shown to
- 15 be recognized by a CTL clone generated with the native WT1 p37-45 epitope. The epitopes identified herein have utility in vaccine and/or immunotherapeutic strategies for the treatment of cancers associated with WT1 expression.

EXAMPLE 31

- 20 THE *IN VIVO* IMMUNOGENICITY OF THE WT1 ANTIGEN

This example describes three *in vivo* immunogenicity studies to evaluate vaccination strategies with WT1 in mice. The three strategies

comprised: 1) a naked DNA vaccine prime and boost; 2) an attenuated adenovirus prime followed by an attenuated alphavirus boost; or 3) a naked DNA prime followed by an adenovirus boost. The full-length cDNA of the splice variant of WT1 used in these studies is set forth in SEQ ID NO:381. The results described herein provide support for the use of WT1 DNA/DNA, DNA/adenovirus or adenovirus/alphavirus prime/boost regimens as vaccine strategies for treating cancers associated with WT1 expression.

In the first study, C57/Bl6 mice were immunized 3 times at 2 week intervals with 100 µg of naked DNA encoding for WT1. Mice were sacrificed 2-3 weeks after the final immunization and CTL were evaluated by standard Chromium release assay. This first study showed that WT1 DNA immunization elicits WT1-specific cytotoxic T cell responses in these mice with a 25:1 E:T ratio showing 40% lysis.

In the second study, HLA-A2/Kb transgenic mice were immunized once with 5×10^8 PFU of attenuated adenovirus encoding WT1 (as described in Example 20) followed 4 weeks later by one boost with 5×10^8 PFU of alphavirus (AlphaVax) encoding WT1. Mice were sacrificed 2-3 weeks after the final immunization and CTL were evaluated by standard Chromium release assay. The results showed that WT1-specific CTL in HLA-A2/Kb transgenic mice specifically lysed dendritic cells (DC) transduced with WT1-expressing viral construct as well as DC pulsed with WT1 peptides. Thus, this immunization strategy also effectively elicits WT1-specific CTL *in vivo*.

In the third study, C57/Bl6 and HLA-A2/Kb transgenic mice were immunized twice with 100 µg of naked WT1 DNA 2 weeks apart followed 3 weeks later by a boost with 7×10^8 PFU adenovirus encoding WT1. Mice were sacrificed 2-3 weeks after the final immunization and CTL were evaluated by IFN-γ ELISPOT assay. The results showed that the WT1 DNA and adenovirus prime-boost generates a WT1-specific CD8 T cell response in HLA-A2/Kb transgenic mice. About 42% of CD8 positive cells stained positive for IFN-γ following a 7 day stimulation with DCs transduced with WT-1. The results from the C57/BL6 mice showed that this immunization strategy generates CD8

responses detectable in fresh splenocytes. Splenocytes were stimulated for 6 hours with pools of 10 15-mer peptides overlapping by 11 amino acids that span the entire WT1 protein. Only cells stimulated with the p121-171 showed IFN- γ staining. About 1.1% of those CD8 T cells stimulated with the p121-171 peptide pool stained positive for IFN- γ . This peptide contains the p117-139 peptide (SEQ ID NO:2) shown in Example 3 to elicit CTL, T helper cell and antibody responses in mice.

In summary, these results show that the three immunization strategies tested herein generate T cell responses *in vivo*. Thus, these studies further confirm the immunogenicity of the WT1 protein and provide support for the use of WT1 DNA/DNA, DNA/adenovirus or adenovirus/alphavirus prime/boost regimens as vaccine strategies for treating cancers associated with WT1 expression.

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EXAMPLE 32

REDUCTION IN WT1+ TUMOR GROWTH IN HLA-A2/Kb TRANSGENIC MICE IMMUNIZED WITH WT1 PROTEIN

This example describes the reduction of WT1+ tumors in transgenic mice immunized with a WT1 vaccine. These results further validate WT1 as a vaccine target and provide support for the use of WT1 in vaccine strategies for treating cancers associated with WT1 expression.

The murine dendritic cell (DC) line DC2.4. was stably transduced with a WT1-LAMP construct (see Example 18, cDNA and protein sequences set forth in SEQ ID NO:382 and 409, respectively). Mice were then inoculated either subcutaneously (s.c.) or intraperitoneally (i.p.) with 2×10^6 cells. This resulted in tumor growth in 80-100% of the mice. The tumors established in mice *in vivo* retained their WT1 expression. Thus, this model provides a system in which to validate the efficacy of WT1 vaccine strategies.

Three groups of A2/Kb mice were then immunized 3 times, 2 weeks apart as follows:

Group 1: saline alone s.c.(control, n=10 mice)

Group 2: MPL-SE 10 μ g alone s.c. (control, n=10 mice)

Group 3: Ra12/WT1 protein 100 μ g + 10 μ g MPL-SE s.c. (n=9 mice)

Two to three weeks after the last WT1 immunization, mice were inoculated with 2×10^6 A2/Kb DC2.4 tumor cells overexpressing WT1. After tumor challenge mice were monitored and tumor size measured twice per week up to 4 weeks after tumor challenge.

The results showed that the percentage of mice with tumor growth in the group that received the WT1 protein vaccine was reduced from about 100% (saline control) or 90% (MPL-SE adjuvant control) to 45% (WT1 protein immunized group). Further, the average tumor volume was reduced in this group from an average tumor size of 1233 cm^3 (saline control) or 753 cm^3 (MPL-SE adjuvant control) observed in the control group to 226 cm^3 in the WT1 protein immunized group. Histopathological analyses showed that tumor margins in vaccinated animals were mixed with host immunological reactions including histiocytes, eosinophils, lymphocytes, mast cells and plasmacytes. Taken together, the results demonstrate that WT1 protein immunization protects against or delays the growth of WT1-positive tumors in the animals immunized with WT1. Thus, these results support the use of WT1 protein as a vaccine for malignancies associated with WT1 expression.

EXAMPLE 33

IDENTIFICATION OF A NATURALLY PROCESSED WT1 CYTOTOXIC T CELL EPITOPE

This example describes the identification of a naturally processed epitope of the WT1 protein recognized by cytotoxic T cells. This experiment further confirms the immunogenicity of the WT1 protein and provides support for its use as a target for vaccine and/or other immunotherapeutic approaches. Additionally, this experiment identifies epitopes of the WT1 protein that may be used in these applications.

HLA-A2/Kb transgenic mice were immunized twice with 100 μ g of naked WT1 DNA 2 weeks apart followed 3 weeks later by a boost with 10^7 PFU

adenovirus encoding WT1. Mice were sacrificed 2-3 weeks after the final immunization and CTL were evaluated by standard chromium release assay. As observed in previous experiments, immunization with WT1 DNA followed by adenoviral boost elicited a WT1-specific CTL response in HLA-A2 transgenic mice. In order to identify which epitopes were recognized by the T cells, CTL lines were generated and cloned by limiting dilution using standard protocols. A positive clone was then tested using as target cells DC2.4 A2/Kb cells pulsed with peptides corresponding to the top 20 predicted HLA-A2 restricted CTL epitopes. The results showed that the WT1 p10-18 9mer peptide (amino acids: ALLPAVPSL, set forth in SEQ ID NO:451) was recognized by this CTL clone. This epitope was previously predicted to be an epitope, as described in Table XLVI, SEQ ID NO:34. In an additional experiment, CTL responses to the p10 peptide were observed in 4 of 5 WT1 immunized animals tested. Thus, this experiment demonstrates that the predicted p10-18 WT1 epitope is naturally processed and recognized by CTLs. Moreover, this experiment confirms the immunogenicity of the WT1 protein and further defines a naturally processed HLA-A2-restricted CTL epitope that can be used in vaccine and immunotherapeutic strategies for the treatment of malignancies associated with WT1 overexpression.

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EXAMPLE 34

WT1 EXPRESSION CONSTRUCTS USING TWIN ARGININE TRANSLOCATOR (TAT) SIGNAL PEPTIDE

This example describes the construction of WT1-TAT vectors and expression of WT1-TAT from these vectors. These constructs have utility in the expression of WT1-TAT molecules for the use in vaccination strategies.

WT-1-F (a.a. 2-281 of the WT1 protein; cDNA and amino acid sequence of 2-281 of WT1 are set forth in SEQ ID NOs:460 and 461, respectively) and full-length WT-1 were constructed as pTAT fusions with no His tag as described below. The cDNA and amino acid sequences of the

30

resulting fusions are set forth in SEQ ID NOs:452 and 453 and SEQ ID NOs:454 and 455, respectively.

The WT-1-F open reading frame was PCR amplified with the following primers:

- 5 PDM-439 (SEQ ID NO:456):
5' GGCTCCGACGTGCGGGACCTGAAC 3' Tm 66°C
PDM-779 (SEQ ID NO:457):
5' CGCGTGAATTCATCACTGAATGCCTCTGAAG 3' Tm 63°C

- 10 The WT-1 full-length open reading frame was amplified with the following primers:

p37 (SEQ ID NO:458): 5' GGCTCCGACGTGCGGGACCTG 3'
p23 (SEQ ID NO:459):
5' GAATTCTCAAAGCGCCAGCTGGAGTTTGGT 3'

15

The PCR conditions were as follows: 1μl 10X Pfu buffer, 1μl 10mM dNTPs 2μl 1μM each oligo 83μl sterile water 1.5μl Pfu DNA polymerase (Stratagene, La Jolla, CA) 50 ng DNA (pPDM FL WT-1). The reaction was denatured at 96°C for 2 minutes followed by 40 cycles of 96°C for 20 seconds, 64°C for 15 seconds, and 72°C for 2 minutes, 30 seconds and a single, final extension of 4 minutes at 72°C.

- 20 The PCR products were digested with EcoRI and cloned into pTAT (a modified pET28 vector with a Twin Arginine Translocation (TAT) signal peptide from the TorA signal peptide in *E. coli* on the N-terminus; see J. Mol. Microbiol. (2000) 2(2): 179-189; Journal of Bacteriology, Jan 2001 p604-610 Vol 183, No 2; Journal of Biochemistry Vol 276, March 16 2001 pp 8159-8164) at the Eco72I and EcoRI sites. The sequences were confirmed through sequence analysis and then transformed into BLR (DE3) pLys S and HMS 174 (DE3) pLysS cells. Expression of the WT1-TAT proteins was confirmed by
- 30 Western analysis.

EXAMPLE 35

THE N-TERMINUS OF WT1 IS THE DOMINANT *IN VIVO* IMMUNOGENIC PORTION OF THE
PROTEIN

In this Example, mice were immunized with different protein
5 constructs of WT-1, (F truncation (2-281) and full length (2-430) as described in
Example 34)) formulated with MPL-SE adjuvant. Improved CD4 responses
were elicited by the truncated constructs relative to the full length protein.
Thus, this example demonstrates that the N-terminal portion of the WT1 protein
spanning from amino acid 2 to 281 is the dominant immunogenic portion of the
10 WT1 protein *in vivo*.

Groups of four C57BL/6 mice were immunized subcutaneously
with 20 µg WT-1 proteins: WT-1-F or WT-1 full length (FL), with Ra12, HIS or
TAT fusions. Immunizations were performed at weeks 0, 3 and 9, and spleens
were harvested at week 11. Splenocytes were then stimulated *in vitro* for 6
15 hours with medium alone, with a 15-mer peptide *p32* (ARMFPNAPYLPSCLE,
amino acids 125-139 of WT-1; found within the p117-139 peptide set forth in
SEQ ID NO:2), with the DC2.4-WT-1/LAMP cell line, or with rRa12. CD4 cells
were then stained for intracellular interferon-gamma and quantified by FACS
analysis. A portion of these splenocytes were then stimulated *in vitro* for 8
20 days, after which CD4+ IFN+ cells were enumerated. After the 6 hour
stimulation with p32, 0.33% of CD4-positive cells were positive for intracellular
IFN-gamma staining in mice immunized with the truncated N-terminal construct
rWT1-F-TAT. By contrast, only 0.10% of CD4-positive cells stained positive for
intracellular IFN-gamma in mice immunized with rWT1-FL-TAT. After the 8 day
25 stimulation, mice immunized with the rWT1-F-TAT construct showed IFN-
gamma staining in 10.72% of the CD4+ cells. By contrast, 0.24% of CD4-
positive cells from mice immunized with the full-length WT1-TAT construct
stained positive for intracellular IFN-gamma. These data indicate that improved
CD4 responses were elicited by the truncated rWT1-TAT construct relative to
30 the full-length rWT1-TAT construct.

In a second assay splenocytes were stimulated *in vitro* with the 23-mer peptide, p117-139 (SEQ ID NO:2; PSQASSGQARMFPNAPYLPSCLE, containing a known CD4 epitope and encompassing "p32"), for 3 days, after which supernatants were assayed for secreted IFN-gamma by ELISA. There was no detectable IFN-gamma secretion from splenocytes from mice immunized with the full-length WT1 constructs. By contrast, an average of 2477 pg/ml IFN-gamma was detected from splenocytes from mice immunized with rWT1-F without a HIS tag. An average of 4658 pg/ml IFN-gamma was detected from splenocytes from mice immunized with rWT1-F-TAT. These data further support the observation that improved CD4 responses were elicited by the truncated N-terminal WT1 constructs relative to the full length protein.

The WT1 protein is a transcription factor which is composed of two functional domains: a proline-glutamine rich domain at the N-terminus, and a zinc finger domain composed of four zinc fingers at the C-terminus with homology to the EGR1/Sp1 family of transcription factors. WT1 is a self-protein. The C-terminus is homologous to other self-proteins and is thus less immunogenic, *i.e.* the subject of a greater degree of immunological tolerance. Of note, the 4 zinc-finger domains within the C-terminus have homology to EGR family members. The results described in this example indicate that tolerance will vary between different portions of a protein, possibly depending on sequence homologies and functional domains.

In summary, the data described in this example support the notion that the most efficient WT1 vaccine will comprise the WT1 N-terminus, either as a recombinant protein or gene-based construct.

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EXAMPLE 36

BACULOVIRUS EXPRESSION CONSTRUCTS FOR EXPRESSION OF THE N-TERMINAL FRAGMENT OF WT1 (WT-1-F: AMINO ACIDS 1-281) AND LARGE SCALE PRODUCTION OF PROTEIN USING INSECT CELLS

The cDNA for the N-terminal fragment of WT-1, together with a Kozak consensus sequence, were obtained by PCR using the WT1-F plasmid

as a template (WT-1-F: amino acids 2-281 of the WT1 protein cloned downstream of a start methionine; cDNA and amino acid sequence of 2-281 of WT1 are set forth in SEQ ID NOs:460 and 461, respectively. The pTAT fusion construct used as template in the experiments described herein is described in

- 5 Example 34. The cDNA of this construct is set forth in SEQ ID NO:452). The following primers were used for amplification:

WT1 F1 (SEQ ID NO:466):

5' CGGCTCTAGAGCCGCCACCATGGGCTCCGACGTGCG

WT1 RV4 (SEQ ID NO:467):

10 5' CGGCTCTAGACTACTGAATGCCTCTGAAGACACCGTG

The cDNA for the same ORF plus a C-terminal 10 residue His Tag was obtained by PCR similarly as above except using WT1RV3 (SEQ ID NO:468) as reverse primer (5'

- 15 CGGCTCTAGACTAATGGTGATGGTGATGATGGTGATGATGCTGAATG
CCTCTGAAGACACCGTG).

- The purified PCR products were cloned into the Xba I site of the donor plasmid, pFastBac1. The recombinant donor plasmid pFBWT1-F (cDNA and amino acid sequences set forth in SEQ ID NOs:463 and 465, respectively) and pFBWT1-FH (with the 10X His Tag; cDNA and amino acid sequence set forth in SEQ ID NOs:462 and 464, respectively) were transformed into *E. coli* strain DH10Bac (Invitrogen, Carlsbad, CA) to make recombinant bacmids in *E. coli* through site-specific transposition. The recombinant bacmids were confirmed by PCR analysis and then transfected into Sf-9 insect cells to make recombinant baculoviruses BVWT1-F and BVWT1-FH. The recombinant viruses were amplified to high titer viral stock in Sf-9 cells.
- 20
25
30

The High Five insect cell line was used to optimize conditions for the protein expression and for the large-scale production of the recombinant proteins. To optimize the conditions for protein expression, High 5 insect cell monolayers were infected with the recombinant baculoviruses BVWT1-F and BVWT1-FH at different multiplicities of infection (MOI) and harvested the

transduced cells at different periods of time. The identities of the proteins were confirmed by Western blot analysis with a rabbit anti-WT1 polyclonal antibody [#942-32 (799L)]. Both WT1-F and WT1-FH recombinant proteins were well expressed at either 48 hours or 54 hours post-infection when High 5 cells were
5 infected by the recombinant viruses at MOI 1.0 or 2.0.

The amplification of the recombinant baculoviruses and the expression of the recombinant WT1-F and WT1-FH proteins was then further optimized. Both BVWT1-F and BVWT1-FH were amplified in the Sf9 insect cell line in ESF921 medium containing 2% fetal calf serum and 0.5X PSF. The
10 amplification was carried out for 4 days at MOI 0.05 at 28°C. The High Five insect cell line was used to optimize conditions for the protein expression. High 5 insect cells were infected by the recombinant baculoviruses at MOIs of 0.5, 1 or 2 for 30, 48, 54, or 72 hours before harvesting. The identity of the recombinant protein was confirmed by Western blot analysis with a specific
15 rabbit polyclonal antibody against WT1 (Antibody #942-32), and by capillary LC-ESI-tandem mass spectrometry. These experiments indicate that optimal protein expression for large scale production of WT1-F and WT1-FH occurs at 43 hours post-infection when High 5 cells were infected by the recombinant viruses at an MOI 0.5-1.0.

20 In summary, the above WT1 baculovirus can be used for large-scale protein production of the N-terminal portion of WT1 for use in a variety of vaccine strategies for the treatment of malignancies associated with WT1 expression.

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EXAMPLE 37

INDUCTION OF *IN VIVO* CD4 AND CD8 T CELL RESPONSES IN MICE USING RECOMBINANT TRICOM VACCINIA AND FOWL POX VECTORS

This example describes *in vivo* immunogenicity studies to
30 evaluate vaccination strategies with WT1 in mice. The purpose of these experiments was to test the ability to rV-WT1/TRICOM and rF-WT1/TRICOM to

induce immunity, in particular T cell immunity, to WT1. The results described herein provide support for the use of TRICOM vaccinia and fowlpox vectors expressing WT1 and containing a triad of costimulatory molecules (B7-1, ICAM-1 and LFA-3) in vaccine strategies for treating cancers associated with

5 WT1 expression.

In the first study, C57Bl/6 mice (12 mice per group) were immunized two or three times with 14 days between the primary, secondary and tertiary immunizations as shown below in Table 1. Mice were harvested at 21 days following the secondary and tertiary immunizations. CD8 and CD4 T cell responses were assayed by IFN- γ intracellular cytokine staining of WT1-peptide activated spleen cells as described in further detail below. CD4 T cell responses were additionally assayed by IFN- γ release from rWT1 protein stimulated spleen cells. Serum IgG₁ and IgG_{2b} antibody responses were assayed by ELISA. T cell responses were evaluated using pooled splenocyte cultures (4 mice/group/time point). Antibody titers were determined for individual mice (4 mice/group/time point).

Table 1: Vaccination Strategy

Groups:
A. Non-immune
B. rWT1 + SE-Vehicle
C. rWT1 + MPL-SE
D. 1 ^o : WT1-DNA, 2 ^o : WT1-DNA, 3 ^o : WT1-Adeno
E. rF-WT1/TRICOM
F. 1 ^o : rV-WT1/TRICOM, 2 ^o : rF-WT1/TRICOM, 3 ^o : rF-WT1/TRICOM
Dose:
rWT1: 50 μ g
MPL-SE: 10 μ g
WT1-DNA: 100 μ g
WT1-Adeno: 5X10 ⁵ pfu
rF-WT1/TRICOM: 1X10 ⁸ pfu

rV-WT1/TRICOM: 1×10^8 pfu
Route:
Subcutaneous (200 ul) immunization for protein/adjuvant and vectors.
Intramuscular immunization (50 ul) for WT1-DNA.

- The full-length cDNA of the splice variant of WT1 used in these studies is set forth in SEQ ID NO:381. The WT1-adenovirus used herein is as described in Example 20. The rF-WT1/TRICOM recombinant fowlpox and the
- 5 rV-WT1/TRICOM recombinant vaccinia vectors both expressing WT1 and containing a triad of costimulatory molecules (B7-1, ICAM-1 and LFA-3) were generated by Theron Biologics (Cambridge, MA, USA).

- To evaluate T cell responses, splenocytes were stimulated *in vitro* with WT1 peptide "p32" (ARMFPNAPYLPSCLE, amino acids 125-139 of WT-1;
- 10 found within the p117-139 peptide set forth in SEQ ID NO:2) known to contain a CTL and a helper T cell epitope. Intracellular cytokine staining for IFN- γ of p125-139 activated splenocytes at 21 days following the secondary immunization showed a significant percentage WT1 responsive CD4⁺ and CD8⁺ T cells in mice immunized with rV-WT1/TRICOM (prime) and
- 15 rF-WT1/TRICOM (boost) whereas no other groups showed significant WT1 specific T cell immune responses. Note that the DNA group was primed and boosted with DNA only. The same group subsequently had an rWT1-Adv tertiary immunization.

- Following tertiary immunization, responses to pools of overlapping
- 20 15-mer peptides were evaluated rather than responses to the single peptide #32. WT1 peptide CD8⁺ and CD4⁺ T-cells specific for peptide pool #32-36 were found to respond at levels similar to the responses following secondary immunization in mice vaccinated with rV-WT1/TRICOM (prime) and rF-WT1/TRICOM (boost X2). In addition, CD4⁺ and CD8⁺ T-cells from these
- 25 mice were found to respond, albeit at a much lower level than peptide #32, to a second WT1 epitope contained within two overlapping 15-mer peptides #57-58 (Peptide 57: DNLQMTSQLECMWTWN (amino acids 224-239); Peptide 58:

MTSQLECMWTWNQMNL (amino acids 229-243); overlap corresponds to amino acid residues 224-243 of WT1).

Antibody responses were evaluated using a standard ELISA.

- Low levels of serum IgG_{2b} antibodies to WT1 were measurable in all 8 mice 21 days post secondary immunization (titer of 1:1350) and 21 days post tertiary immunization (titer of 1:3325) in mice immunized with rWT1 + MPL-SE. By contrast, in all other groups serum IgG_{2b} antibodies titers were <1:100 (Table 2).

10 Table 2: Antibody Responses in WT1-Immunized Mice

Group	Serum Titers*			
	Secondary		Tertiary	
	IgG ₁	IgG _{2b}	IgG ₁	IgG _{2b}
Non-immune	ND	ND	ND	ND
WT1 + Vehicle-SE	<75	<100	475	<50
WT1 + MPL-SE	<50	1350	338	3325
WT1-DNA, WT1-DNA, WT1-Adeno	ND	ND	ND	ND
rF-WT1/TRICOM	ND	ND	<50	<50
rV-WT1/TRICOM, rFWT1/TRICOM	ND	<50	<50	ND

* Serum titers are the average of 4 mice per group. Titers written as <50, <75, or <100 were also averages, but in all instances less than 4 mice had detectable titers. ND indicates antibody was not detected in any of the mice.

- 15 In summary, immunization of C57Bl/6 mice with rV-WT1/TRICOM (prime) followed by rF-WT1/TRICOM (boost) or by WT1-DNA (prime) followed by WT1-Adeno (boost) elicited both CD8 and CD4 T cell responses against WT1. The T cell responses to rV-WT1/TRICOM followed by rF-WT1/TRICOM versus WT1-DNA followed by WT1-Adeno were equivalent within the power of
20 the experimental design. Without being bound by theory, a major advantage of

rF-WT1/TRICOM is that multiple boosts can continue to increase the level of immunity. Thus, these studies further confirm the immunogenicity of the WT1 protein and provide support for the use of WT1 DNA/adenovirus or rV-WT1/TRICOM/rF-WT1/TRICOM immunization regimens in vaccine strategies for treating cancers associated with WT1 expression.

EXAMPLE 38

CONSTRUCTION OF THE STUMPY-WT1-F VECTOR FOR EXPRESSION OF WT1-F IN *E.*

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This example describes the construction of an expression vector containing a truncated twin arginine translocator (TAT) signal peptide fused to the WT1-F reading frame (2-281 N-terminal portion of the WT1 protein). This vector can be used to produce a single species truncated TAT-WT1-F protein for use in immunization strategies for the treatment of malignancies associated with expression of WT1.

As described previously in Example 34, the TAT signal sequence was used to make various WT1 vectors. When these TAT vectors were used in expression, multiple forms of the protein were observed. N-terminal sequencing of these forms showed that each of the three separate proteins being expressed were truncations of the TAT peptide. These cleavages were occurring at each of the twin arginine sites. Thus, a truncated TAT vector was constructed to shorten the TAT signal peptide from 39 amino acids to 12 amino acids to avoid generation of these cleavage products during expression. The TAT "Stumpy" vector was generated by maintaining the first 12 residues of the TAT signal peptide up to the first twin arginine. This vector was constructed as follows:

30

The following pairs of oligonucleotides were combined and then annealed.

Pair 1:

Stumpy 1 (SEQ ID NO:486): 5' taigaacaataacgacgtctgttcaggc 3'

Stumpy 3 (SEQ ID NO:487): 5' CTGAAACAGATCGTTATTGTTCA 3'

Pair 2:

5 Stumpy 4 (SEQ ID NO:488): 5' aattctgtgctcattcacgtggcggtcgc 3'

Stumpy 2 (SEQ ID NO:489): 5' gagccgccacgtgaatgaccaag 3'

The pairs were then ligated together with pPDM, a modified pET28 vector, that had been digested with NdeI and EcoRI. The resulting plasmid, pStumpy, is set forth in SEQ ID NO:471. The amino acid sequence of the truncated TAT protein is set forth in SEQ ID NO:506. The full-length TAT polynucleotide is set forth in SEQ ID NO:503 and encodes the amino acid sequence of the TAT polypeptide set forth in SEQ ID NO:504.

The pStumpy vector was then used to construct the Stumpy-WT1-F vector to express the N-terminal portion of WT1 without cleavage products. The Stumpy-WT1-F vector was constructed as follows:

The coding region of WT1-F was PCR amplified with the following primer set:

PDM-1005 (SEQ ID NO:484):
 20 5' GGCTCCGACGTTTCGGGACCTGAACGCACTG 3'
 PDM-1004 (SEQ ID NO:485):
 5' CTGCAGAATTCATCACTGAATGCCTCTGAAG 3'

The amplification reaction contained 10 ul 10X Pfu buffer, 1 ul 10mM dNTPs, 2 ul each 10 uM primer, 83 ul sterile water, and 1.5 ul Pfu DNA polymerase (Stratagene, La Jolla, CA). The reaction was first denatured for 2 minutes at 96°C followed by 40 cycles of 96°C for 20 seconds, 63°C for 15 seconds, and 72°C for 30 seconds. The reaction was then extended for a final extension of 72°C for 4 minutes.

30 The PCR product was then digested with EcoRI and cloned into the pStumpy vector that had been digested with EcoRI and EcoRI. The

construct was confirmed through sequence analysis and then transformed into BLR (DE3) pLys S cells. The resulting truncated TAT WT1-F fusion protein expressed as a single species. The polynucleotide sequence of the coding region of pStumpy WT1-F is set forth in SEQ ID NO:469 which encodes the amino acid sequence set forth in SEQ ID NO:470.

EXAMPLE 39

CONSTRUCTION OF WT1-F GMP, WT1-G, AND WT1-DELTA G VECTORS FOR EXPRESSION IN *E. COLI*

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This example describes the construction of WT1-F, WT1-G, and WT1-Delta G vectors optimized for protein production in *E. coli*.

The TAT WT-1 F DNA sequence was codon optimized and synthetically engineered by Blue Heron Biotechnology (Bothel, WA) to be optimized for expression in *E. coli*. This codon optimized cDNA sequence of WT1-F is set forth in SEQ ID NOs:477 and encodes the amino acid sequence set forth in SEQ ID NO:479. The plasmid containing this sequence was then digested with NdeI and EcoRI and sub-cloned into a modified pET28 vector that had been digested with NdeI and EcoRI for expression in *E. coli*. This construct was confirmed to be correct by DNA sequence analysis and then transformed into BLR (DE3) pLys S cells for expression. This construct is a purely synthetic traceable source of TAT WT1-F template DNA.

The codon optimized sequence was then used as template for PCR to delete a proline rich region of fourteen amino acids from the N-terminal region (deletion of amino acids 54-67 of WT-1 F sequence set forth in SEQ ID NO:461; corresponding to amino acids 55-68 of full-length WT1), creating the WT-1 G cDNA sequence set forth in SEQ ID NO:473 which encodes the amino acid sequence set forth in SEQ ID NO:478. This was done by first generating the pTAT-WT-1 G construct as follows:

30

The 5' coding region of WT-1 G was PCR amplified using the following primer set:

PDM-1007 (SEQ ID NO:490) 5'
caagcgctcatgagcccggaagtggcgagccc 3' Tm 76°C

PDM-1006 (SEQ ID NO:491) 5'
cataaattggcccgcccgcccgagagcg 3' Tm 76°C

5 The 3' coding region of the WT-1 G region was PCR amplified
using the following primer set:

PDM-1008 (SEQ ID NO:492) 5' cattcatcatcaaacaggagcc 3' Tm
61°C

10 PDM-1009 (SEQ ID NO:493) 5' ccattaagaattcatcactgaatacc 3' Tm
60°C

The PCR reaction for amplification of WT1-G contained 10 ul 10X
Pfu buffer, 1 ul 10 mM dNTPs, 2 ul each 10 uM primer, 83 ul sterile water, 1.5
ul Pfu DNA polymerase (Stratagene, La Jolla, CA), and 50 ng DNA template
(pTAT WT1-F codon optimized as set forth in SEQ ID NO: 477). The reaction
15 was first denatured for 2 minutes at 96°C followed by 40 cycles of 96°C for 20
seconds, 63°C for 15 seconds, and 72°C for 30 seconds. The reaction was
then extended for a final extension of 72°C for 4 minutes.

The first PCR product was then digested with XbaI and cloned
into pPDM (a modified pET28 vector) that had been digested with XbaI and
20 Eco72I. The resulting construct (pTAT WT1-GA) was then digested with SrfI
and EcoRI. The second PCR construct was digested with EcoRI and cloned
into the pTAT WT1-GA plasmid construct. At the same time a three-way
ligation was carried out by digesting the first PCR construct with XbaI and SrfI
and digesting the second PCR construct with EcoRI and cloning into pPDM that
25 had been digested with XbaI and EcoRI. The resulting pTAT-WT1-G construct
was confirmed to be correct through sequence analysis and then transformed
into an expression host. The cDNA of pTAT-WT1-G is set forth in SEQ ID
NO:475 and encodes the amino acid sequence of SEQ ID NO:482.

30 Due to incomplete SrfI digestion during the second method
described above, an unexpected form of WT-1 G (WT-1 Delta G was created
that deleted 14 amino acids (amino acids 55-68 of WT-1 F) and added three

- additional amino acids (WT-1 Delta G polynucleotide sequence set forth in SEQ ID NO:505 which encodes the polypeptide sequence set forth in SEQ ID NO:502). This TAT WT-1 Delta G construct resulted in an unexpected 5-fold over expression as compared to the TAT WT-1 F constructs. The cDNA of the
- 5 pTAT-WT1 Delta G construct is set forth in SEQ ID NO:476 and encodes the amino acid sequence set forth in SEQ ID NO:481.

Following generation of the pTAT-WT-1 G, pStumpy-WT1 G and WT1-G with and without a His tag were constructed using the pTAT-WT1 G as a template in the PCR reactions described below.

- 10 The coding region of the WT1-G region was PCR amplified using the following primer sets:

PCR 1:

PDM-1010 (SEQ ID NO:494) 5' gggtcggatgtacgcgatctgaacg 3' Tm 68°C

- 15 PDM-1011 (SEQ ID NO:495) 5' caaagaattcatcactgaataccgcg 3' Tm 63°C

PCR 2:

- 20 PDM-1023 (SEQ ID NO:496) 5' gcttttggcatatgggtcggatgtacgcgatc 3' Tm 71°C

PDM-1011 (SEQ ID NO:497) 5' caaagaattcatcactgaataccgcg 3' Tm 63°C

- 25 The PCR reaction and amplification conditions were as described above using the pTAT-WT1 G set forth in SEQ ID NO:475 as template. The first PCR product was digested with EcoRI and cloned into pPDM (a modified pET28 vector with a his tag in-frame) and pSTUMPY (a modified pET28 vector with a 12 amino acid truncated TAT leader peptide in frame set forth in SEQ ID
- 30 NO:471) that were digested with EcoRI and Eco72I. The second PCR product was digested with NdeI and EcoRI and cloned into a modified pET28 vector

(pPDM) that had been digested with NdeI and EcoRI. The constructs were confirmed to be correct through sequence analysis and then transformed into an expression host. The resulting constructs are as follows: The polynucleotide of WT1-G with His tag is set forth in SEQ ID NO:472 and encodes the amino acid sequence set forth in SEQ ID NO:480. The polynucleotide of WT1-G without His tag is set forth in SEQ ID NO:473 which encodes the amino acid sequence set forth in SEQ ID NO:478. The pStumpy-WT1-G polynucleotide sequence is set forth in SEQ ID NO:474 and encodes the amino acid sequence set forth in SEQ ID NO:483.

In a related experiment, the pStumpy WT-1 F GMP (codon optimized) vector was constructed as follows:

The coding region of the WT-1 F region was amplified using the following primers

PDM-1010 (SEQ ID NO:500) 5' ggctcggaatgtacgcgatctgaacg 3' Tm

68oC

PDM-1011 (SEQ ID NO:501) 5' caaagaattcatcactgaataccgcg 3'

Tm 63oC

The PCR reaction and amplification conditions were as described above using pTAT WT-1F GMP as template. The PCR product was digested with EcoRI and cloned into the pStumpy vector described in Example 38 that was digested with EcoRI and Eco72I. The construct was confirmed to be correct through sequence analysis and then transformed into an expression host. The polynucleotide sequence of pStumpy WT-1 F GMP is set forth in SEQ ID NO:498 which encodes the amino acid sequence of SEQ ID NO:499.

In summary, the expression vectors described herein can be used for optimal expression and production of WT1, truncated WT1, and WT1 fusion proteins for use in vaccine strategies for the treatment of malignancies associated with expression of WT1.

From the foregoing it will be appreciated that, although specific embodiments of the invention have been described herein for purposes of illustration, various modifications may be made without deviating from the spirit and scope of the invention. Accordingly, the invention is not limited except as

5 by the appended claims.

CLAIMS

What is Claimed:

1. An isolated polypeptide comprising an immunogenic portion of a Wilms' tumor antigen, selected from the group consisting of SEQ ID NOs:414-450, 478, and 502, or a variant thereof that differs in one or more substitutions, deletions, additions and/or insertions such that the ability of the variant to react with WT1-specific antisera and/or T-cell lines or clones is not substantially diminished.
2. The isolated polypeptide according to claim 1 wherein the immunogenic portion has been modified such that the ability of the immunogenic portion to bind to an MHC molecule is increased relative to that of the immunogenic portion.
3. The isolated polypeptide according to claim 2 wherein the immunogenic portion has been modified such that the ability of the immunogenic portion to bind to HLA-A2 is increased relative to that of the unmodified immunogenic portion.
4. An isolated polypeptide comprising a Wilms' tumor antigen having a deletion of a proline rich region.
5. An isolated polypeptide according to claim 4 wherein said proline rich region is from about amino acid positions 54 to 68 of the Wilms' tumor antigen.
6. The isolated polypeptide of claim 5 wherein said polypeptide comprises the amino acid sequence set forth in any one of SEQ ID NO:478 and 502.

7. A fusion protein comprising at least one polypeptide according to any one of claims 1, 2 or 4.

8. The fusion protein of claim 7 wherein said fusion partner is selected from the group consisting of Ra12, protein D, LYTA, a HIS tag, a targeting signal capable of directing a polypeptide to the endosomal/lysosomal compartment, twin arginine translocator, and truncated twin arginine translocator.

9. The fusion protein of claim 8 wherein the fusion protein comprises a twin arginine translocator signal peptide.

10. The fusion protein of claim 8 wherein the fusion partner comprises the amino acid sequence of any one of SEQ ID NOs:504 and 506.

11. The fusion protein of claim 10 wherein the fusion protein comprises the amino acid sequence of any one of SEQ ID NOs:453, 455, 470, 479-483, and 499.

12. An isolated polynucleotide encoding the fusion proteins of any one of claims 7, 9, and 11.

13. The isolated polynucleotide of claim 12 wherein the polynucleotide has been codon optimized for expression in *E. coli*.

14. The isolated polynucleotide of claim 12 wherein the polynucleotide comprises a sequence of any one of SEQ ID NOs:452, 454, 469, 471, and 472-477 and 503, 505.

15. A composition comprising a polypeptide of claim 1, 4, 6, or 11 in combination with a pharmaceutically acceptable carrier or excipient.

16. A vaccine comprising a polypeptide of claim 1, 4, 6, or 11 in combination with a non-specific immune response enhancer.

17. The vaccine according to claim 15 wherein the non-specific immune response enhancer preferentially enhances a T cell response in a patient.

18. The vaccine according to claim 15, wherein the immune response enhancer is selected from the group consisting of 3d-MPL, MPL, RC-529, AGP's, Montanide ISA50, Seppic Montanide ISA 720, a cytokine, a microsphere, dimethyl dioctadecyl ammoniumbromide (DDA) based adjuvants, AS-1, AS-2, Ribi Adjuvant system based adjuvant, QS21, saponin based adjuvants, Syntex adjuvant in its microfluidized form, MV, ddMV, immune stimulating complex (iscom) based adjuvants, and inactivated toxins.

19. An expression vector comprising a polynucleotide of claim 12 operably linked to an expression control sequence.

20. A host cell transformed or transfected with an expression vector according to claim 19.

21. An isolated polypeptide comprising an immunogenic portion of the Wilms' tumor antigen wherein said polypeptide has been modified such that the ability of the polypeptide to bind HLA-A2 is increased and wherein the immunogenicity of the polypeptide is increased relative to that of SEQ ID NO:241.

22. The isolated polypeptide of claim 21 wherein said polypeptide comprises an amino acid sequence selected from the group consisting of any one of SEQ ID NOs:414-450.

23. The isolated polypeptide of claim 21, wherein said modification comprises one or more substitutions at any one of positions 1 through 9 of SEQ ID NO:241.

24. The isolated polypeptide according to claim 23 wherein said modification comprises a substitution at position 6 (P6) of SEQ ID NO:241.

25. The isolated polypeptide of claim 24 wherein said polypeptide comprises the amino acid sequence set forth in SEQ ID NO:445

26. The isolated polypeptide according to claim 23 wherein said modification comprises a substitution at position 9 (P9) of SEQ ID NO:241.

27. The isolated polypeptide according to claim 26 wherein said polypeptide comprises an amino acid sequence set forth in SEQ ID NO:426.

28. A method for inducing an immune response in an animal, comprising:

(a) administering to said animal a first composition comprising a first viral vector wherein said first viral vector comprises at least an immunogenic portion of a WT1 polynucleotide operably linked to an expression control sequence;

(b) administering to said animal a second composition comprising a second viral vector wherein said second viral vector comprises at least an immunogenic portion of a WT1 polynucleotide operably linked to an expression control sequence; and

thereby inducing an immune response in the animal.

29. The method of claim 28 wherein said first and said second viral vectors are selected from the group consisting of vaccinia vectors, fowlpox vectors, and adenoviral vectors.

30. The method of claim 29 wherein said first viral vector comprises a recombinant vaccinia vector.

31. The method of claim 28 wherein said first viral vector comprises rV-WT1/TRICOM.

32. The method of claim 28 wherein said second viral vector comprises a recombinant fowlpox vector.

33. The method of claim 28 wherein said second viral vector comprises rF-WT1/TRICOM.

34. The method of claim 28 wherein said first and said second viral vectors further comprise at least one polynucleotide encoding a costimulatory molecule.

35. The method of claim 28 wherein said costimulatory molecule is selected from the group consisting of B7-1, ICAM-1, and LFA-3.

36. The method of claim 28 wherein said first composition is administered at a first timepoint and said second composition is administered subsequently at a second and a third timepoint.

37. A method for inducing an immune response in a patient comprising administering to the patient a composition comprising a first component comprising an amino acid sequence set forth in any one of 414-450, 453, 455, 470, 478, 479-483, 499, and 502 and a second component

selected from any one or both of a physiologically acceptable carrier or immunostimulant.

38. A method for inducing an immune response in a patient comprising administering to the patient a composition comprising a first component comprising a polynucleotide encoding a polypeptide comprising an amino acid sequence set forth in any one of 414-450, 453, 455, 470, 478, 479-483, 499, and 502 and a second component comprising a polypeptide comprising an amino acid sequence set forth in any one of 414-450, 453, 455, 470, 478, 479-483, 499, and 502.

HU: MGSVDRLNALLPAVPSLGGGGGALPVSGAAQWAPVLDAPPASAYGSL
 NO: MGSVDRLNALLPAVSSLGGGGGGLPVSGAAQWAPVLDAPPASAYGSL

 HU: GGPAPPPAPPPPPPHSFJKQEPSMGGAEPHEEQCLSAFTVHFSQFTGTAG
 NO: GGPAPPPAPPPPPPHSFJKQEPSMGGAEPHEEQCLSAFTLHFSQFTGTAG

 HU: ACRYGPGPPPSQASSGQARMFNPAPYLPSCLESQPAIRNOGYSTVTFDGTPS
 NO: ACRYGPGPPPSQASSGQARMFNPAPYLPSCLESQPTIRNOGYSTVTFDGAPS

 HU: YGHTPSHAAQFPNHSFKHEDPMGQGSLSGEQQYSVPPPVYGHPTPTDSCG
 NO: YGHTPSHAAQFPNHSFKHEDPMGQGSLSGEQQYSVPPPVYGHPTPTDSCG

 HU: SQALLRTPYSSDNLVQMTSQLECHTNQNLGATLKGYAAGSSSSVKWTE
 NO: SQALLRTPYSSDNLVQMTSQLECHTNQNLGATLKGYAAGSSSSVKWTE

 HU: GQSNHSTGYESDNHTPTILCGAQYRIHTHGVFRGIQVRRVPGVAPTLVRSAS
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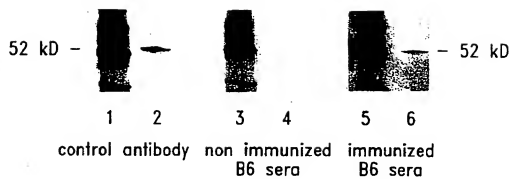
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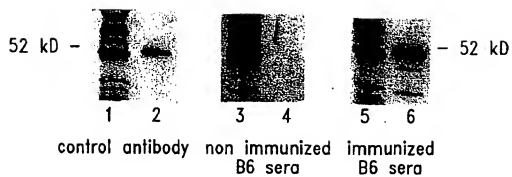
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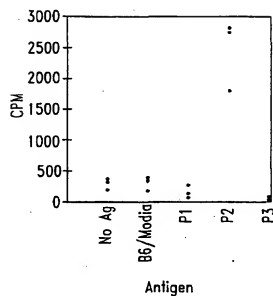
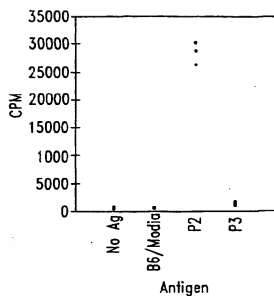
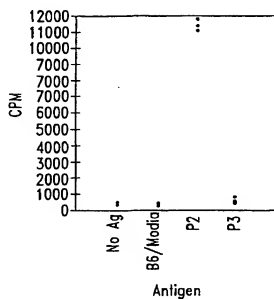
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 NO: WPSQCKKFARSDLVRRHNNHQRNMTKLHVAL

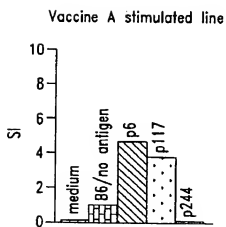
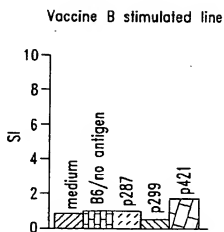
Fig. 1

*Fig. 2*

*Fig. 3*

*Fig. 4*

*Fig. 5A**Fig. 5B**Fig. 5C*

*Fig. 6A**Fig. 6B*

p117-139 stimulated line

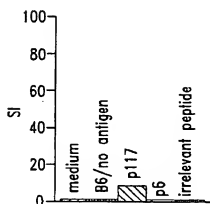


Fig. 7A

p117-139 stimulated clone

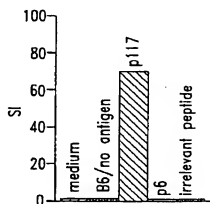


Fig. 7B

p6-22 stimulated line

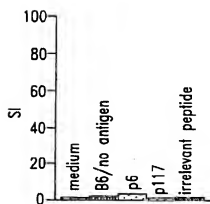


Fig. 7C

p6-22 stimulated clone

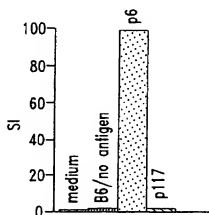


Fig. 7D

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.....AAAAAAAAAAAAAAAA.....AAAAA.....AAAAAAAAAAAA
.....RRRR.....
.....

80  85  90  95  100 105 110 115 120 125 130 135 140 145 150
PSMGAEPEHEEQCLSAFTVHFSQFTGTAGACRYGPGFPPPSQASSGQARMFNPAPYLPSCLESQPAIRNQGS
.....AAA.....AAAA.....AAA.....AAAAA.....
.....RRRR.....RRRR.....
.....DDDDDDDD.....

155 160 165 170 175 180 185 190 195 200 205 210 215 220 225
TVTFDGTPSYGHTPSHAAQFPHHSFKHEDPMGQGSLSGEQQYSVPPPPVYGCHTPTDSCTSQALLRTPYSSDN
.....AAAA.....AAAA.....AA
.....RRRR.....
.....DDDDDDDDDDDD.....

230 235 240 245 250 255 260 265 270 275 280 285 290 295 300
LYQHTSQL ECHTWQMLGATLKGVAAGSSSSVKWTEGQSNHSTGYESDNHTTPLLCGAQYRIHTHGWFG1QDV
AAAAAA.....AAA.AAA.....AAAAAAAAAA
.....RRRRRRRRRR.....RRRR.....RRRR.....
DDDDDD.....DDDDDDDDDD.....dadd.....

305 310 315 320 325 330 335 340 345 350 355 360 365 370 375
RRVPGVAPTLVRSASETSEKRP7MCAYPGCHKRYFKLSHLQMSRXJHTGEPYQCFKDCERRFSRSDQLKRHQR
AAAAA.....AAAAAA.....AAAA.AAAAAAA.
.....RRRR.....RRRR.....
.....DDDDDD.....

380 385 390 395 400 405 410 415 420 425 430 435 440 445 450
RHTGVKPFQCKTCQRKFSRSDHLKTHTRTHTGKTSKPFSCRNPSCQKQFARSDELVRHHNHQRNMTKLQAL
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.....RRRR.....RRRR.....
.....daddddddd.....

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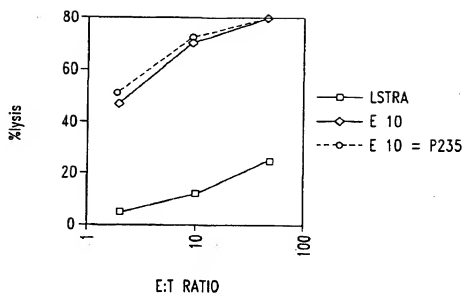
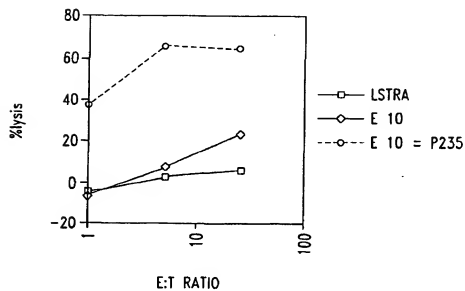
Fig. 8A

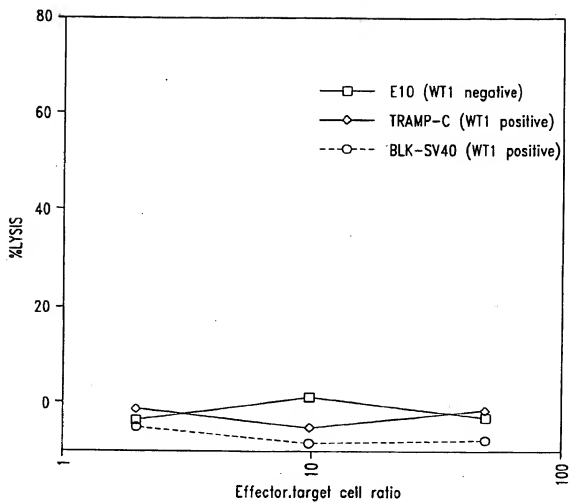

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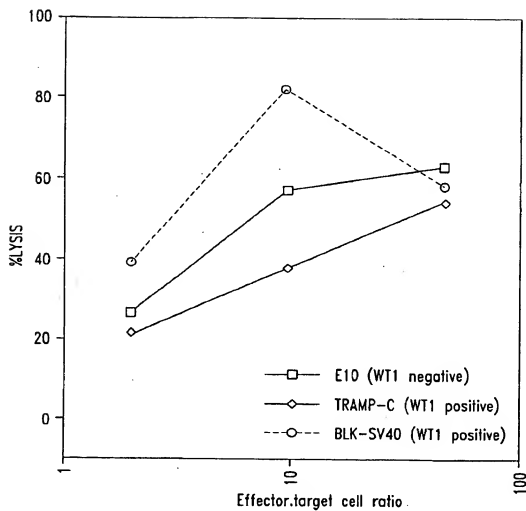
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.....AAAAAAAAAAAAAAAA.....AAAAA.....AAAAAAAAA.....
.....RRRR.....
.....
.....
.....
80  85  90  95  100 105 110 115 120 125 130 135 140 145 150
PSMGGAEPHEEQCLSAFTLHFSQGTGTAGACRYGPGPPPSQASSGDAHMFNAPYLPSCLESQPTIRNGYS
.....AAAA.....AAA.....AAAAA.....
.....RRRR.....RRRR.....
.....DDDDDDDD.....
.....
.....
155 160 165 170 175 180 185 190 195 200 205 210 215 220 225
TVTFDGPSPYGHPTSHHAQFPNHSFKHEDPMGQGSGLGEQYTSVPPPYGCHTPTDSCCTGSQALLRTPYSSDN
.....AAAA.....AAAAA.....AA.....
.....RRRR.....
.....DDDDDDDDDDDDDD.....
.....
.....
230 235 240 245 250 255 260 265 270 275 280 285 290 295 300
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AAAAAAA.....AAA.AAA.....AAAAAAAAAAAA.....
.....RRRRRRRRRR.....RRRR.....RRRR.....
DDDDDD.....DDDDDDDDDD.....
.....ddddd.....
.....
305 310 315 320 325 330 335 340 345 350 355 360 365 370 375
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AAAAA.AAAAAAAAAA.....AAAA.AAAAAAAAAA.....
.....RRRRR.....RRRR.....
.....DDDDDDDDDD.....
.....
.....
380 385 390 395 400 405 410 415 420 425 430 435 440 445 450
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.....

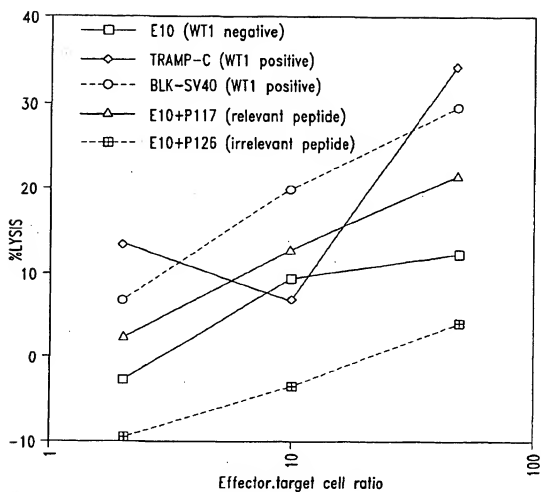
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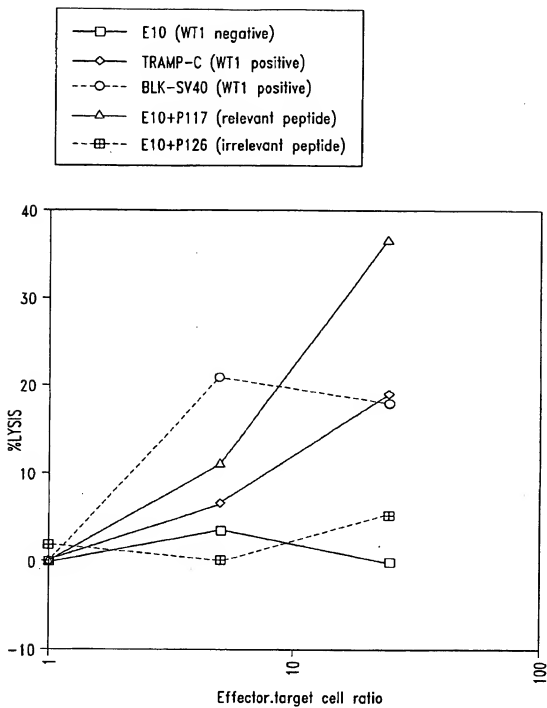
Fig. 8B

*Fig. 9A**Fig. 9B*

*Fig. 10A*

*Fig. 10B*

*Fig. 10C*

*Fig. 10D*

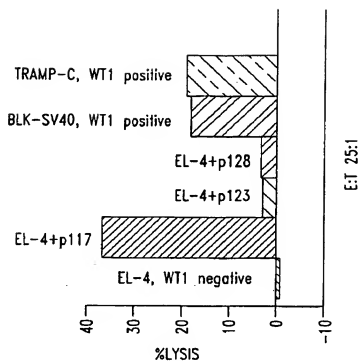


Fig. 11B

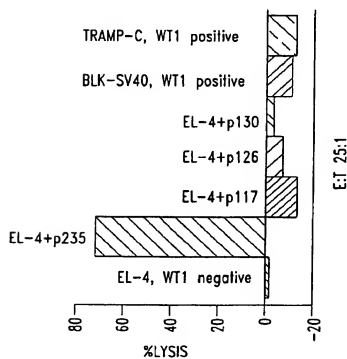
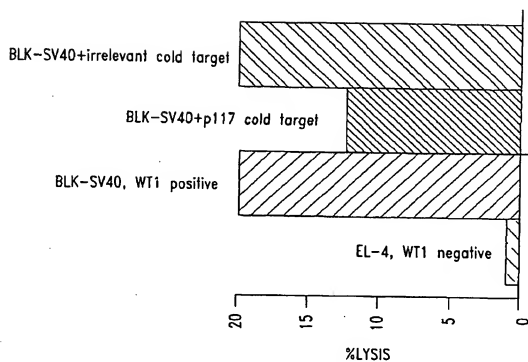
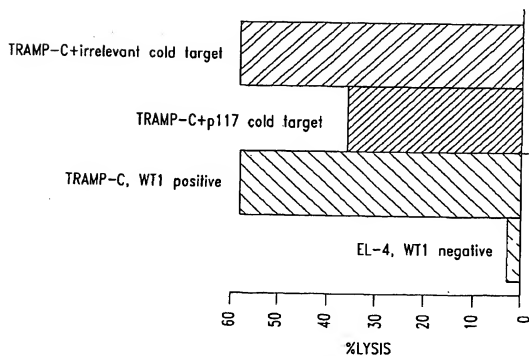
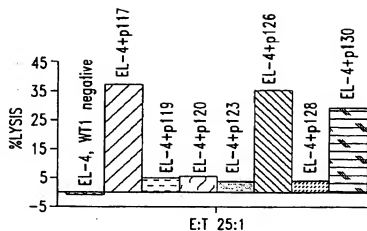
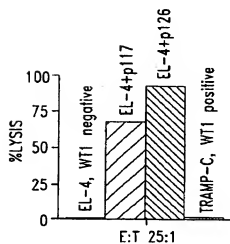
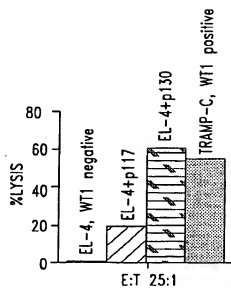
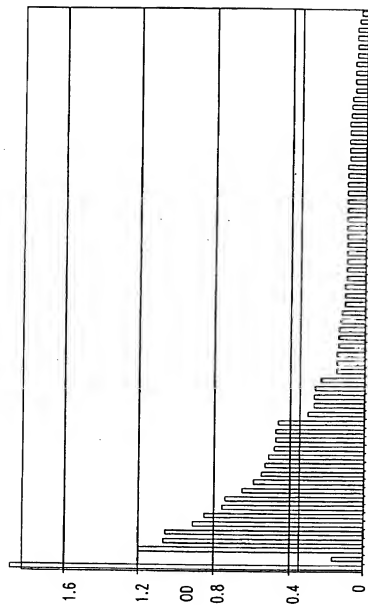
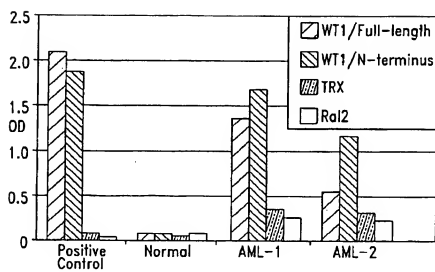


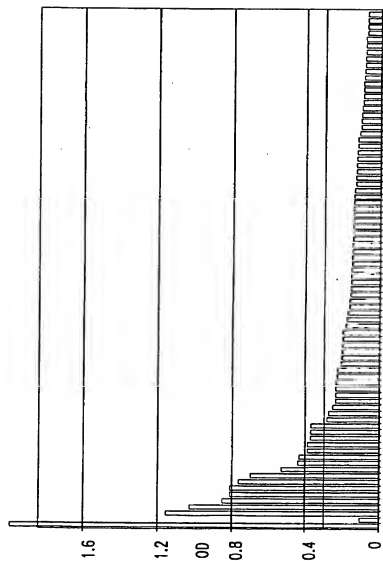
Fig. 11A

ET 25:1
Fig. 12BET 25:1
Fig. 12A

*Fig. 13A**Fig. 13B**Fig. 13C*

*Fig. 14*

*Fig. 15*

*Fig. 16*

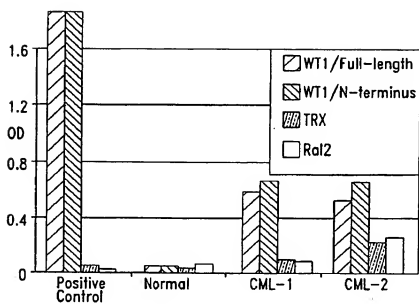
*Fig. 17*

TABLE 1: Characteristics of Recombinant WT1 Proteins Used for Serological Analysis

<u>NAME</u>	<u>Recombinant Protein</u>	<u>WT1 Amino Acid Position</u>	<u>Molecular Weight</u>
WT1/full-length	Ra2-WT1 full length fusion protein	aa 1-449	85kDa
WT1/N-terminus	TRX-WT1 N-terminus fusion protein	aa 1-249	60kDa
WT1/C-terminus	WT1 C-terminus protein	aa 267-449	50kDa

Fig. 18

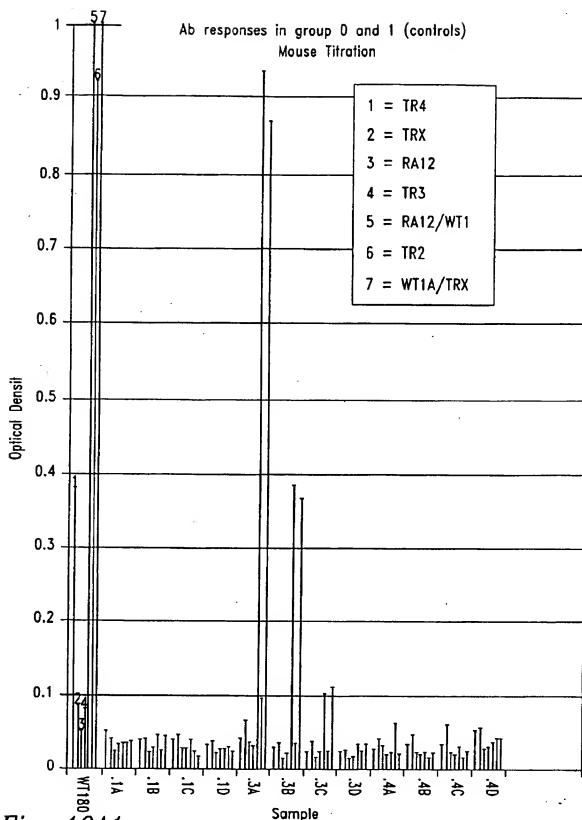
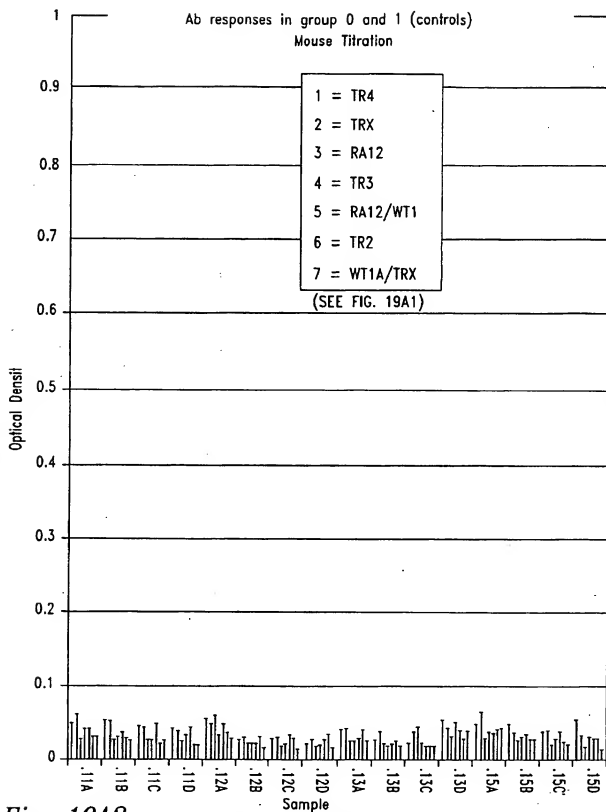
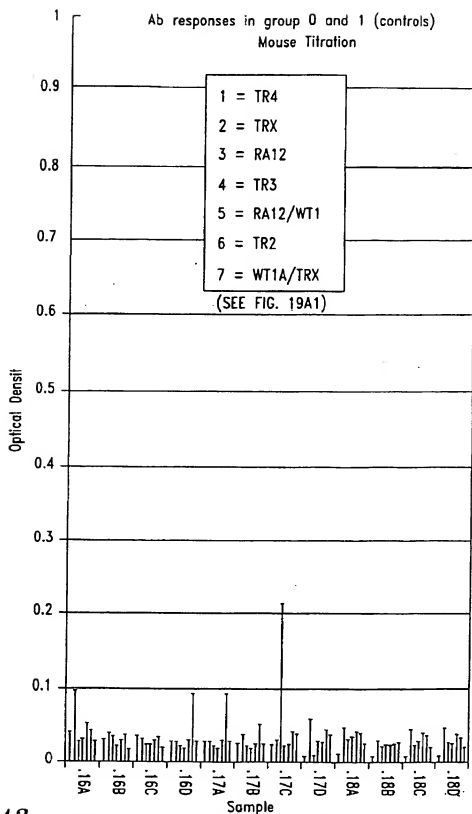
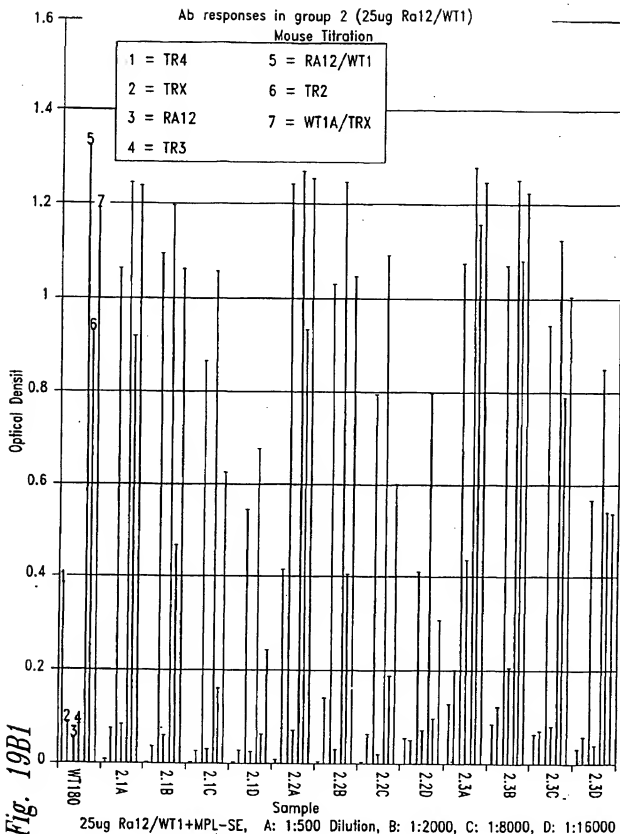


Fig. 19A1

Control groups. A: 1:500 Dilution, B: 1:2000, C: 1:8000, D: 1:16000







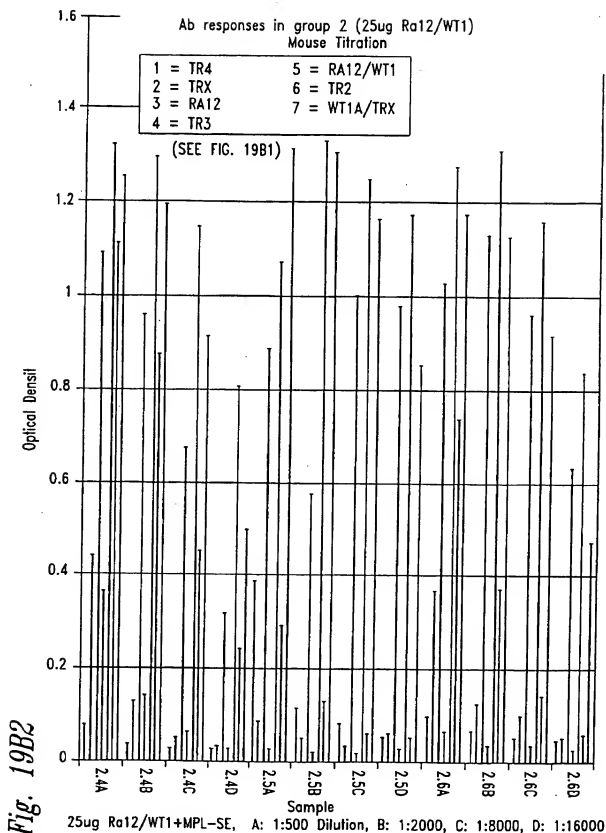
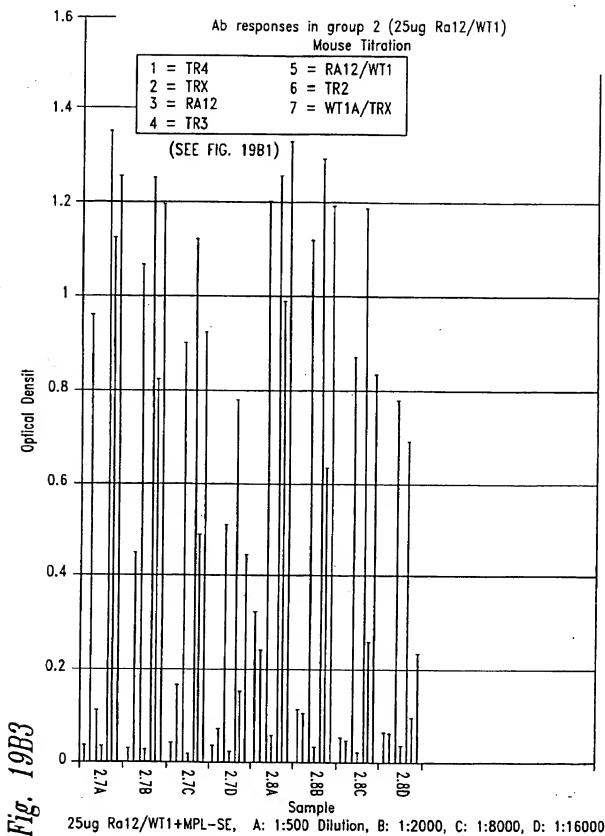


Fig. 19B2



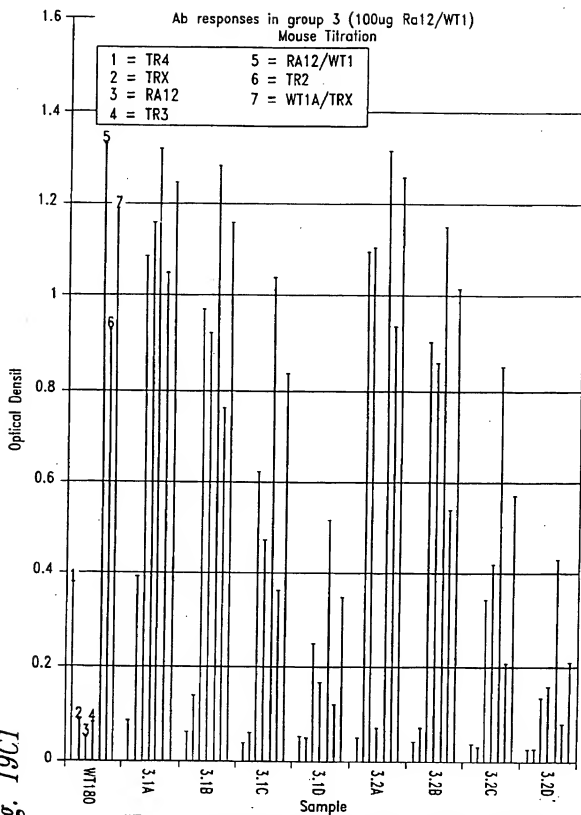
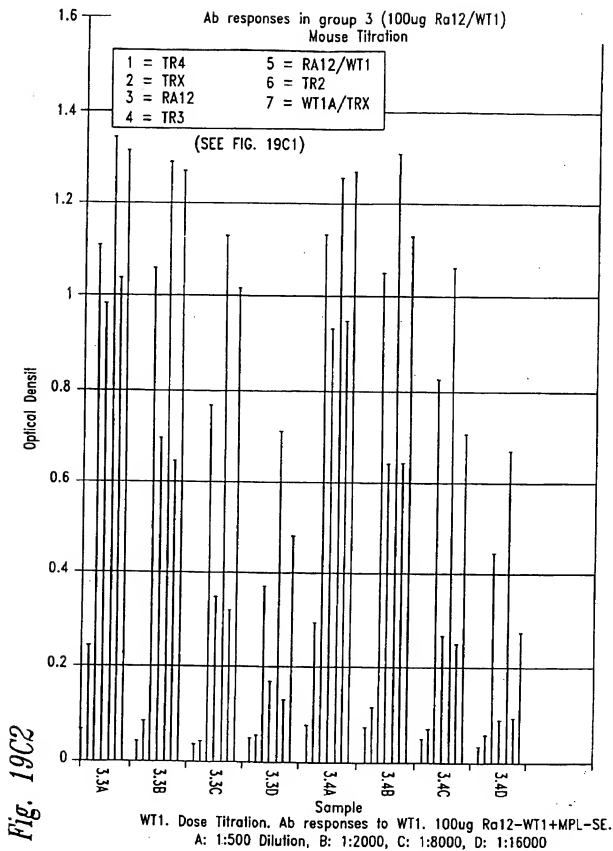


Fig. 19C1

WT1. Dose Titration. Ab responses to WT1. 100ug Ra12-WT1+MPL-SE.
A: 1:500 Dilution, B: 1:2000, C: 1:8000, D: 1:16000



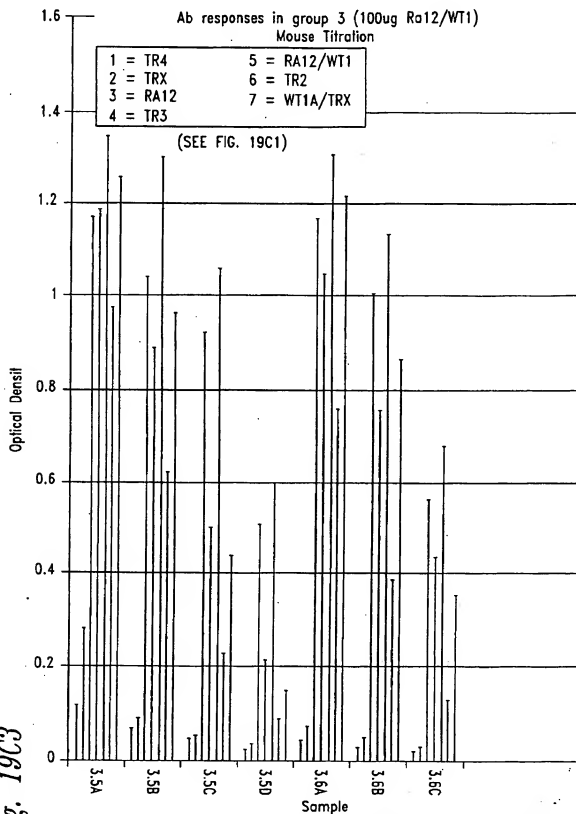


Fig. 19C3

WT1. Dose Titration. Ab responses to WT1. 100ug Ra12-WT1+MPL-SE.
A: 1:500 Dilution, B: 1:2000, C: 1:8000, D: 1:16000

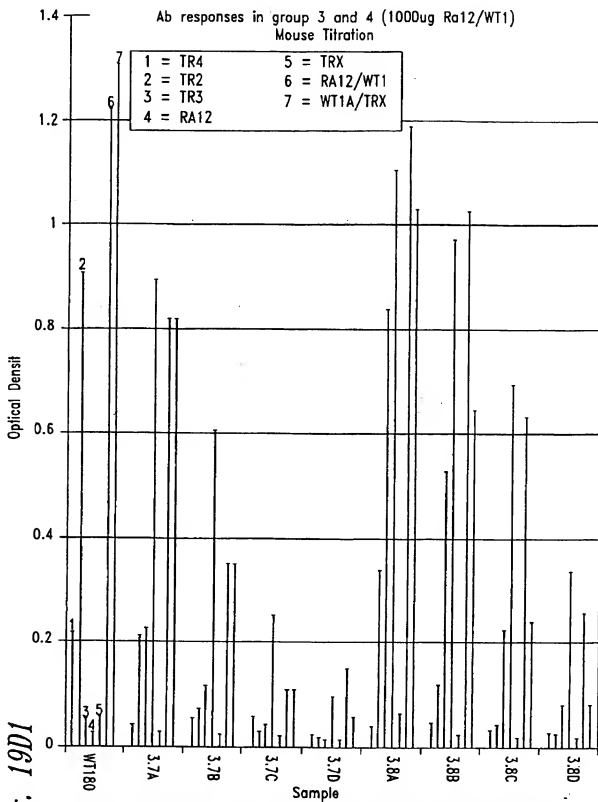
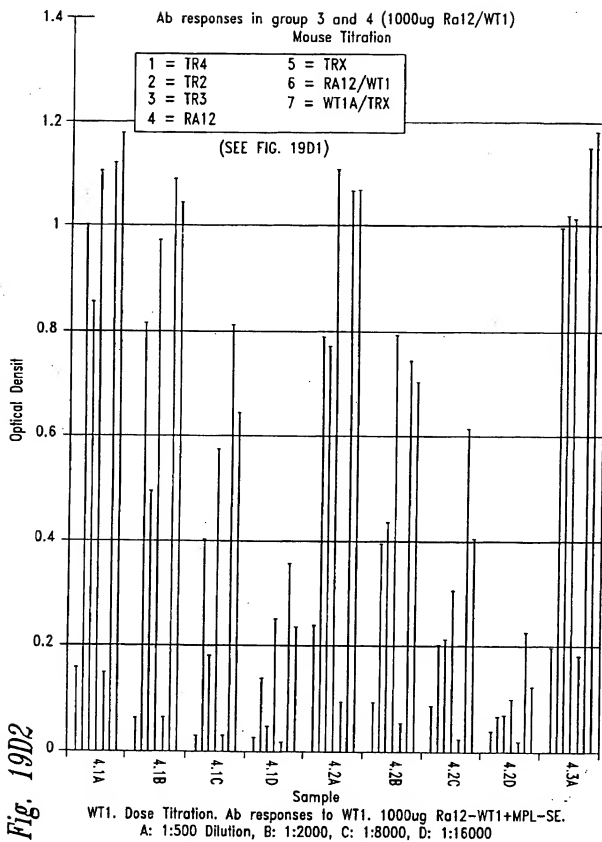


Fig. 19D1

WT1. Dose Titration. Ab responses to WT1. 1000ug Ra12-WT1+MPL-SE.
A: 1:500 Dilution, B: 1:2000, C: 1:8000, D: 1:16000



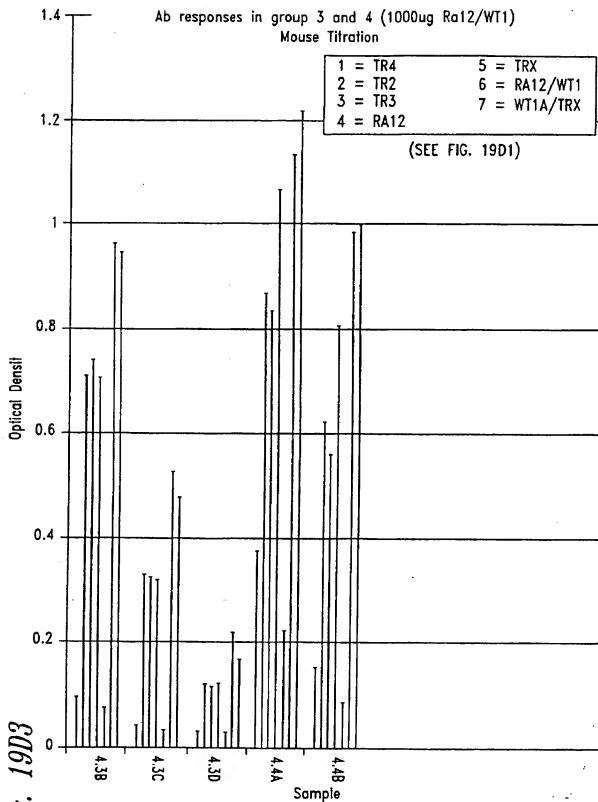


Fig. 19D3

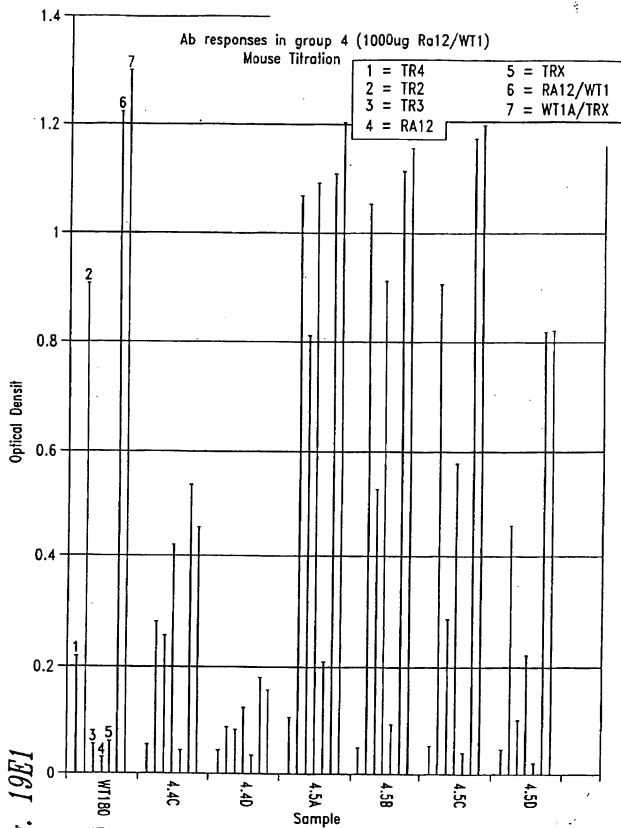


Fig. 19E1

WT1. Dose Titration. Ab responses to WT1. 1000ug Ra12-WT1+MPL-SE.
A: 1:500 Dilution, B: 1:2000, C: 1:8000, D: 1:16000

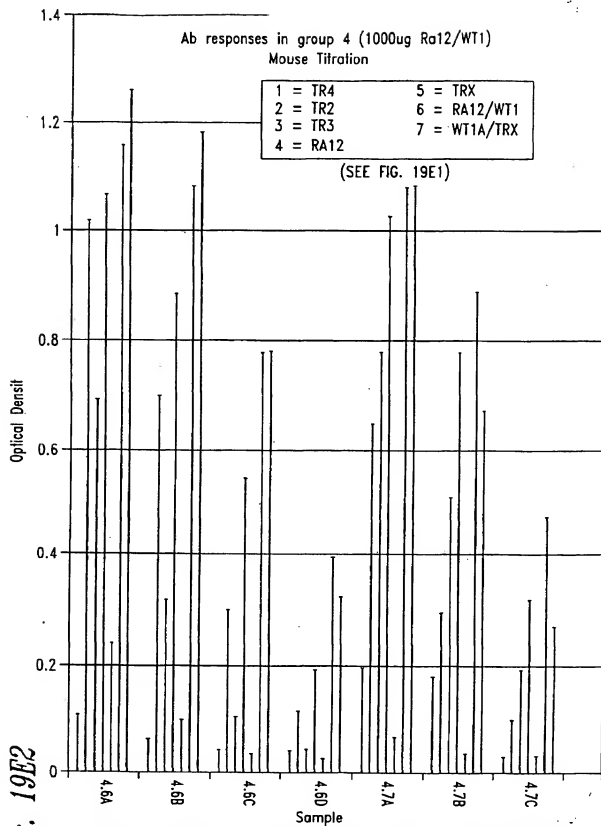


Fig. 19E2

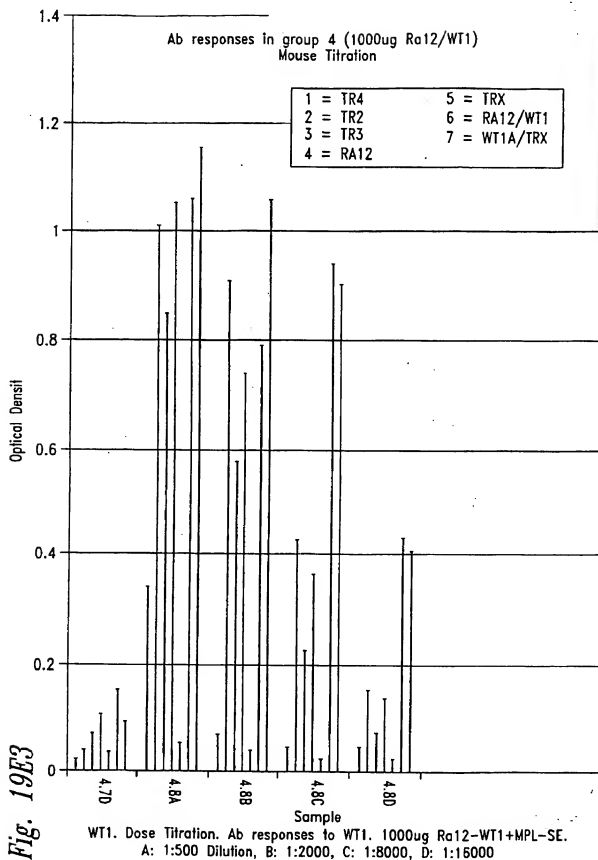


Fig. 19E3

Proliferative T-cell responses in WT1 protein immunized mice. (Ra12WT1 dose titration, 3x in vivo, after 2VS)

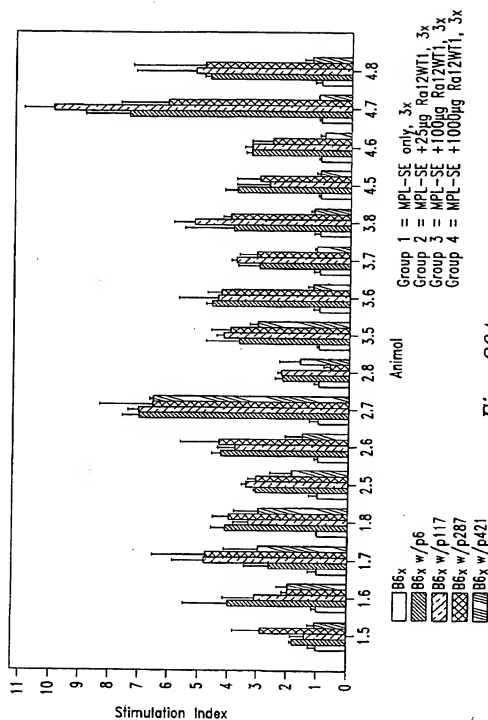


Fig. 20A

Proliferative T-cell responses in WT1 protein immunized mice. (Ra12WT1 dose titration, 5x in vivo, after 21VS)

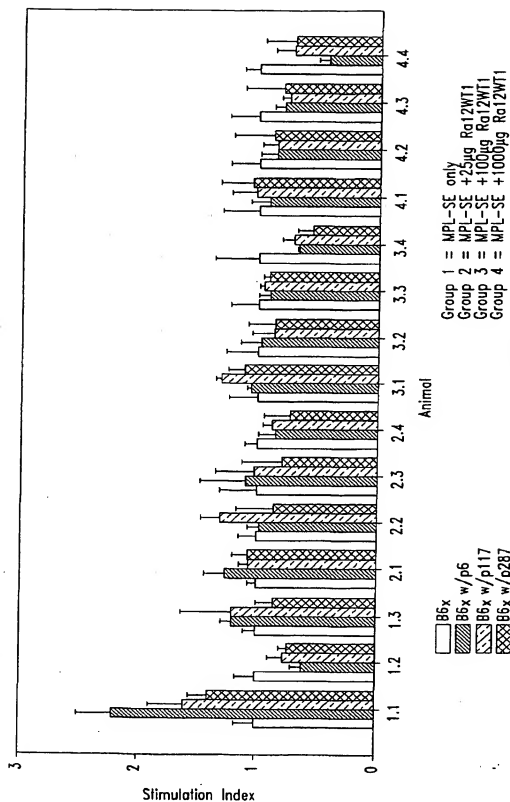
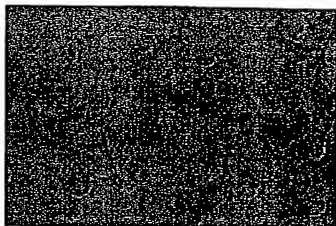


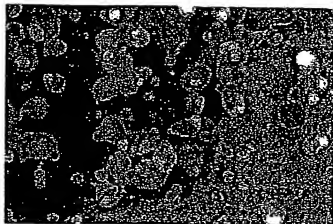
Fig. 20B

WT1 expression in human DC following adeno
WT1 and Vaccinia WT1 infection

Control
(uninfected human DC)



Adeno WT1
(infected human DC)



Vaccinia WT1
(infected human DC)

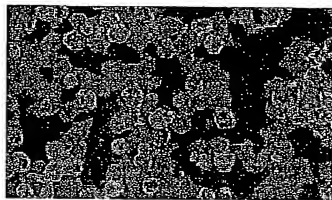
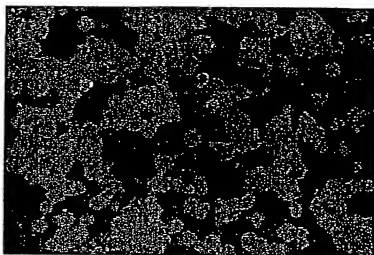


Fig. 21

WT1 can be expressed reproducibly in human DC
following adeno WT1 infection and is not
induced by a control Adeno infection

Control
(Adeno EGFP
infected human DC)



Vaccinia WT1
(infected human
DC)

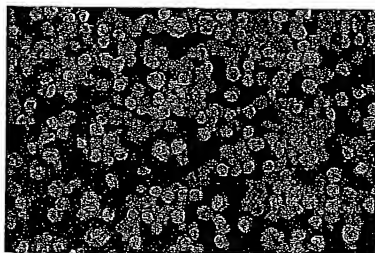
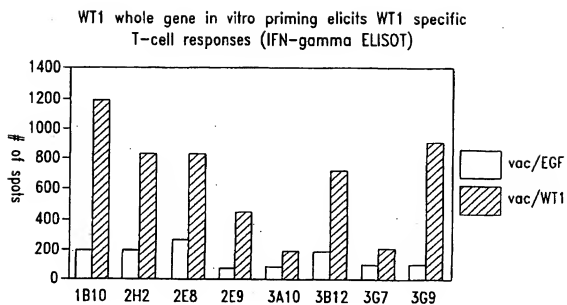


Fig. 22

*Fig. 23*

WT-1 F cDNA 2-281

[illegible]

WT-1 F amino acid 2-281

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Fig. 24

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 Gaiger, Alexander
 McNeill, Patricia D.
 Jaya, Nomalie
 Carter, Darrick

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<211> 9
<212> PRT
<213> Mus musculus

<400> 288
Gln Ala Ser Ser Gly Gln Ala Arg Met
1 5

<210> 289
<211> 9
<212> PRT
<213> Mus musculus

<400> 289
Gln Met Thr Ser Gln Leu Glu Cys Met
1 5

<210> 290
<211> 9
<212> PRT
<213> Mus musculus

<400> 290
Gln Gln Tyr Ser Val Pro Pro Pro Val
1 5

<210> 291
<211> 9
<212> PRT
<213> Mus musculus

<400> 291
Gln Tyr Arg Ile His Thr His Gly Val
1 5

<210> 292
<211> 9
<212> PRT
<213> Mus musculus

<400> 292
Gln Tyr Ser Val Pro Pro Pro Val Tyr
1 5

<210> 293
<211> 9
<212> PRT
<213> Mus musculus

<400> 293
Arg Met Phe Pro Asn Ala Pro Tyr Leu
1 5

<210> 294
<211> 9
<212> PRT
<213> Mus musculus

<400> 294
Arg Thr Pro Tyr Ser Ser Asp Asn Leu
1 5

<210> 295
<211> 9
<212> PRT
<213> Mus musculus

<400> 295
Arg Val Ser Gly Val Ala Pro Thr Leu
1 5

<210> 296
<211> 9
<212> PRT
<213> Mus musculus

<400> 296
Ser Cys Leu Glu Ser Gln Pro Thr Ile
1 5

<210> 297
<211> 9
<212> PRT
<213> Mus musculus

<400> 297
Ser Cys Gln Lys Lys Phe Ala Arg Ser
1 5

<210> 298
<211> 9
<212> PRT
<213> Mus musculus

<400> 298
Ser Asp Val Arg Asp Leu Asn Ala Leu
1 5

<210> 299
<211> 9
<212> PRT
<213> Mus musculus

<400> 299
Ser Leu Gly Glu Gln Gln Tyr Ser Val
1 5

<210> 300
<211> 9
<212> PRT
<213> Mus musculus

<400> 300
Thr Cys Gln Arg Lys Phe Ser Arg Ser
1 5

<210> 301
<211> 9
<212> PRT
<213> Mus musculus

<400> 301
Thr Glu Gly Gln Ser Asn His Gly Ile
1 5

<210> 302
<211> 9
<212> PRT
<213> Mus musculus

<400> 302
Thr Leu His Phe Ser Gly Gln Phe Thr
1 5

<210> 303
<211> 9
<212> PRT
<213> Mus musculus

<400> 303
Thr Leu Val Arg Ser Ala Ser Glu Thr
1 5

<210> 304
<211> 9
<212> PRT
<213> Mus musculus

<400> 304
Val Leu Asp Phe Ala Pro Pro Gly Ala
1 5

<210> 305
<211> 9
<212> PRT
<213> Mus musculus

<400> 305
Trp Asn Gln Met Asn Leu Gly Ala Thr
1 5

<210> 306
<211> 9
<212> PRT
<213> Mus musculus

<400> 306
Tyr Phe Lys Leu Ser His Leu Gln Met
1 5

<210> 307
<211> 9
<212> PRT
<213> Mus musculus

<400> 307
Tyr Gln Met Thr Ser Gln Leu Glu Cys
1 5

<210> 308
<211> 9
<212> PRT

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<213> Mus musculus

<400> 308
Tyr Ser Ser Asp Asn Leu Tyr Gln Met
1          5

<210> 309
<211> 6
<212> PRT
<213> Homo sapien

<400> 309
Gly Ala Ala Gln Trp Ala
1          5

<210> 310
<211> 12
<212> PRT
<213> Homo sapien

<400> 310
Ala Ser Ala Tyr Gly Ser Leu Gly Gly Pro Ala Pro
1          5          10

<210> 311
<211> 15
<212> PRT
<213> Homo sapien

<400> 311
Ala Phe Thr Val His Phe Ser Gly Gln Phe Thr Gly Thr Ala Gly
1          5          10          15

<210> 312
<211> 5
<212> PRT
<213> Homo sapien

<400> 312
His Ala Ala Gln Phe
1          5

<210> 313
<211> 32
<212> PRT
<213> Homo sapien

<400> 313
Cys His Thr Pro Thr Asp Ser Cys Thr Gly Ser Gln Ala Leu Leu Leu
1          5          10          15
Arg Thr Pro Tyr Ser Ser Asp Asn Leu Tyr Gln Met Thr Ser Gln Leu
          20          25          30

<210> 314
<211> 32
<212> PRT
<213> Homo sapien

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50

<400> 314
 Arg Ile His Thr His Gly Val Phe Arg Gly Ile Gln Asp Val Arg Arg
 1 5 10 15
 Val Pro Gly Val Ala Pro Thr Leu Val Arg Ser Ala Ser Glu Thr Ser
 20 25 30

<210> 315
 <211> 4
 <212> PRT
 <213> Homo sapien

<400> 315
 Arg Tyr Phe Lys
 1

<210> 316
 <211> 14
 <212> PRT
 <213> Homo sapien

<400> 316
 Glu Arg Arg Phe Ser Arg Ser Asp Gln Leu Lys Arg His Gln
 1 5 10

<210> 317
 <211> 22
 <212> PRT
 <213> Homo sapien

<400> 317
 Gln Arg Lys Phe Ser Arg Ser Asp His Leu Lys Thr His Thr Arg Thr
 1 5 10 15
 His Thr Gly Lys Thr Ser
 20

<210> 318
 <211> 21
 <212> PRT
 <213> Homo sapien

<400> 318
 Cys Gln Lys Lys Phe Ala Arg Ser Asp Glu Leu Val Arg His His Asn
 1 5 10 15
 Met His Gln Arg Asn
 20

<210> 319
 <211> 449
 <212> PRT
 <213> Homo sapien

<400> 319
 Met Gly Ser Asp Val Arg Asp Leu Asn Ala Leu Leu Pro Ala Val Pro
 1 5 10 15
 Ser Leu Gly Gly Gly Gly Gly Cys Ala Leu Pro Val Ser Gly Ala Ala
 20 25 30
 Gln Trp Ala Pro Val Leu Asp Phe Ala Pro Pro Gly Ala Ser Ala Trp
 35 40 45

Gly Ser Leu Gly Gly Pro Ala Pro Pro Pro Ala Pro Pro Pro Pro Pro
 50 55 60
 Pro Pro Pro Pro His Ser Phe Ile Lys Gln Glu Pro Ser Trp Gly Gly
 65 70 75 80
 Ala Glu Pro His Glu Glu Gln Cys Leu Ser Ala Phe Thr Val His Phe
 85 90 95
 Ser Gly Gln Phe Thr Gly Thr Ala Gly Ala Cys Arg Tyr Gly Pro Phe
 100 105 110
 Gly Pro Pro Pro Ser Gln Ala Ser Ser Gly Gln Ala Arg Met Phe
 115 120 125
 Pro Asn Ala Pro Tyr Leu Pro Ser Cys Leu Glu Ser Gln Pro Ala Ile
 130 135 140
 Arg Asn Gln Gly Tyr Ser Thr Val Thr Phe Asp Gly Thr Pro Ser Tyr
 145 150 155 160
 Gly His Thr Pro Ser His His Ala Ala Gln Phe Pro Asn His Ser Phe
 165 170 175
 Lys His Glu Asp Pro Met Gly Gln Gln Gly Ser Leu Gly Glu Gln Gln
 180 185 190
 Tyr Ser Val Pro Pro Pro Val Tyr Gly Cys His Thr Pro Thr Asp Ser
 195 200 205
 Cys Thr Gly Ser Gln Ala Leu Leu Leu Arg Thr Pro Tyr Ser Ser Asp
 210 215 220
 Asn Leu Tyr Gln Met Thr Ser Gln Leu Glu Cys Met Thr Trp Asn Gln
 225 230 235 240
 Met Asn Leu Gly Ala Thr Leu Lys Gly Val Ala Ala Gly Ser Ser Ser
 245 250 255
 Ser Val Lys Trp Thr Glu Gly Gln Ser Asn His Ser Thr Gly Tyr Glu
 260 265 270
 Ser Asp Asn His Thr Thr Pro Ile Leu Cys Gly Ala Gln Tyr Arg Ile
 275 280 285
 His Thr His Gly Val Phe Arg Gly Ile Gln Asp Val Arg Arg Val Pro
 290 295 300
 Gly Val Ala Pro Thr Leu Val Arg Ser Ala Ser Glu Thr Ser Glu Lys
 305 310 315 320
 Arg Pro Phe Met Cys Ala Tyr Pro Gly Cys Asn Lys Arg Tyr Phe Lys
 325 330 335
 Leu Ser His Leu Gln Met His Ser Arg Lys His Thr Gly Glu Lys Pro
 340 345 350
 Tyr Gln Cys Asp Phe Lys Asp Cys Glu Arg Arg Phe Ser Arg Ser Asp
 355 360 365
 Gln Leu Lys Arg His Gln Arg Arg His Thr Gly Val Lys Pro Phe Gln
 370 375 380
 Cys Lys Thr Cys Gln Arg Lys Phe Ser Arg Ser Asp His Leu Lys Thr
 385 390 395 400
 His Thr Arg Thr His Thr Gly Lys Thr Ser Glu Lys Pro Phe Ser Cys
 405 410 415
 Arg Trp Pro Ser Cys Gln Lys Lys Phe Ala Arg Ser Asp Glu Leu Val
 420 425 430
 Arg His His Asn Met His Gln Arg Asn Met Thr Lys Leu Gln Leu Ala
 435 440 445
 Leu

<210> 320
 <211> 449
 <212> PRT
 <213> Mus musculus

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<400> 320
Met Gly Ser Asp Val Arg Asp Leu Asn Ala Leu Leu Pro Ala Val Ser
1      5      10      15
Ser Leu Gly Gly Gly Gly Cys Gly Leu Pro Val Ser Gly Ala Ala
20     25     30
Gln Trp Ala Pro Val Leu Asp Phe Ala Pro Pro Gly Ala Ser Ala Tyr
35     40     45
Gly Ser Leu Gly Gly Pro Ala Pro Pro Ala Pro Pro Pro Pro
50     55     60
Pro Pro Pro Pro His Ser Phe Ile Lys Gln Glu Pro Ser Trp Gly Gly
65     70     80
Ala Glu Pro His Glu Glu Gln Cys Leu Ser Ala Phe Thr Leu His Phe
85     90     95
Ser Gly Gln Phe Thr Gly Thr Ala Gly Ala Cys Arg Tyr Gly Pro Phe
100    105    110
Gly Pro Pro Pro Ser Gln Ala Ser Ser Gly Gln Ala Arg Met Phe
115    120    125
Pro Asn Ala Pro Tyr Leu Pro Ser Cys Leu Glu Ser Gln Pro Thr Ile
130    135    140
Arg Asn Gln Gly Tyr Ser Thr Val Thr Phe Asp Gly Ala Pro Ser Tyr
145    150    155
Gly His Thr Pro Ser His His Ala Ala Gln Phe Pro Asn His Ser Phe
160    165    170
Lys His Glu Asp Pro Met Gly Gln Gln Gly Ser Leu Gly Glu Gln Gln
175    180    185
Tyr Ser Val Pro Pro Pro Val Tyr Gly Cys His Thr Pro Thr Asp Ser
190    195    200
Cys Thr Gly Ser Gln Ala Leu Leu Arg Thr Pro Tyr Ser Ser Asp
205    210    215
Asn Leu Tyr Gln Met Thr Ser Gln Leu Glu Cys Met Thr Trp Asn Gln
220    225    230
Met Asn Leu Gly Ala Thr Leu Lys Gly Met Ala Ala Gly Ser Ser Ser
235    240    245
Ser Val Lys Trp Thr Glu Gly Gln Ser Asn His Gly Ile Gly Tyr Glu
250    255    260
Ser Asp Asn His Thr Ala Pro Ile Leu Cys Gly Ala Gln Tyr Arg Ile
265    270    275
His Thr His Gly Val Phe Arg Gly Ile Gln Asp Val Arg Arg Val Ser
280    285    290
Gly Val Ala Pro Thr Leu Val Arg Ser Ala Ser Glu Thr Ser Glu Lys
295    300    305
Arg Pro Phe Met Cys Ala Tyr Pro Gly Cys Asn Lys Arg Tyr Phe Lys
310    315    320
Leu Ser His Leu Gln Met His Ser Arg Lys His Thr Gly Glu Lys Pro
325    330    335
Tyr Gln Cys Asp Phe Lys Asp Cys Glu Arg Arg Phe Ser Arg Ser Asp
340    345    350
Gln Leu Lys Arg His Gln Arg Arg His Thr Gly Val Lys Pro Phe Gln
355    360    365
Cys Lys Thr Cys Gln Arg Lys Phe Ser Arg Ser Asp His Leu Lys Thr
370    375    380
385    390    395
His Thr Arg Thr His Thr Gly Lys Thr Ser Glu Lys Pro Phe Ser Cys
400    405    410
Arg Trp His Ser Cys Gln Lys Lys Phe Ala Arg Ser Asp Glu Leu Val
415    420    425
Arg His His Asn Met His Gln Arg Asn Met Thr Lys Leu His Val Ala
430    435    440
445
Leu

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<210> 321
<211> 9
<212> PRT
<213> Homo sapien and Mus musculus

<400> 321
Pro Ser Gln Ala Ser Ser Gly Gln Ala
1 5

<210> 322
<211> 9
<212> PRT
<213> Homo sapien and Mus musculus

<400> 322
Ser Ser Gly Gln Ala Arg Met Phe Pro
1 5

<210> 323
<211> 9
<212> PRT
<213> Homo sapien and Mus musculus

<400> 323
Gln Ala Arg Met Phe Pro Asn Ala Pro
1 5

<210> 324
<211> 9
<212> PRT
<213> Homo sapien and Mus musculus

<400> 324
Met Phe Pro Asn Ala Pro Tyr Leu Pro
1 5

<210> 325
<211> 9
<212> PRT
<213> Homo sapien and Mus musculus

<400> 325
Pro Asn Ala Pro Tyr Leu Pro Ser Cys
1 5

<210> 326
<211> 9
<212> PRT
<213> Homo sapien and Mus musculus

<400> 326
Ala Pro Tyr Leu Pro Ser Cys Leu Glu
1 5

<210> 327

<211> 1029

<212> DNA

<213> Homo sapiens

<400> 327

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atgcagcatc accaccatca ccacatgagc gataaaatta ttcacctgac tgacgacagt 60
tttgacacgg atgtactcaa agcggacggg gcgatctctg tcgatttctg ggcagagtgg 120
tgcggtccgt gcaaaatgat cgcgcccgatt ctggatgaaa tcgctgacga atatcagggc 180
aaactgacgg ttgcaaaact gaacatcgat caaaacctg gcactgcgcc gaaatatggc 240
atccgtggta tcccgactct gctgctgttc aaaaacgggt aagtggcgcc aaccaaaagt 300
ggtgcactgt ctaaagggtca gttgaaagag ttctctgacg ctaacctggc cggttctgg 360
tctggccata tgcagcatca ccaccatcac cactgttcta tcgaaggctg tctagctct 420
ggtggcagcg gtctggttcc gcgtggtagc tctggttcgg gggacgacga cgacaaatct 480
agtaggcaca gcacagggtta cgagagcgat aaccacacaa cgcctactct ctgcggagcc 540
caatacacaa tacacacgca cgggtgtctc agaggcattc aggatgtgcg acgtgtgcct 600
ggagttagccc cgactcttgt acggtcgcca tctgagacca gtgagaaacg cccctctatg 660
tgtgttacc caggctgcga taagagatat tttaagctgt cccacttaca gatgcacagc 720
aggaagcaca ctggtgagaa accataccag tgtgacttca aggaacttga acgaaggtt 780
ttctggtcag accagctcaa aagacaccaa aggagacata caggtgtgaa accattccag 840
tgtaaaaact gtcagcgaaa gttctccggg tccgaccacc tgaagaccac caccaggact 900
catcacgggtg aaaaagccct cagctgtcgg tggccaaagt tgcagaaaaa gtttgcggcg 960
tcagatgaat tagtccgccca tcacaacatg catcagagaa acatgaccaa actccagctg 1020
gcgcttga                                     1029

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<210> 328

<211> 1233

<212> DNA

<213> Homo sapiens

<400> 328

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atgcagcatc accaccatca ccacatgagc gataaaatta ttcacctgac tgacgacagt 60
tttgacacgg atgtactcaa agcggacggg gcgatctctg tcgatttctg ggcagagtgg 120
tgcggtccgt gcaaaatgat cgcgcccgatt ctggatgaaa tcgctgacga atatcagggc 180
aaactgacgg ttgcaaaact gaacatcgat caaaacctg gcactgcgcc gaaatatggc 240
atccgtggta tcccgactct gctgctgttc aaaaacgggt aagtggcgcc aaccaaaagt 300
ggtgcactgt ctaaagggtca gttgaaagag ttctctgacg ctaacctggc cggttctgg 360
tctggccata tgcagcatca ccaccatcac cactgttcta tcgaaggctg tctagctct 420
ggtggcagcg gtctggttcc gcgtggtagc tctggttcgg gggacgacga cgacaaatct 480
agtagggggt ccgagcttgc tgacctgaac gcactgtctg cggcagttcc gtccctgggt 540
ggtggtgggt gttgcgcact gccggttagc ggtgcagcac agtgggtccc ggttctggac 600
tctgcacccg cgggtgcact cgcatacggg tccctgggtg gtccggcacc gccgcggcca 660
ccgcgccgcc gccgcgccgc gccgcgccgc tcccttcatca aacagggaacc gagctgggt 720
ggtgcagaac cgcacgaaga acagtgctgt agcgcattea ccgttcaact ctccggccag 780
tctactggca cagccggagc ctgtcgctac gggcccttcc gctctcctcc cccacgccag 840
cgctcatccg gccaggccag gatgtttcct aacgcgccct acctgccagc ctgcctcgag 900
agccaccccg ctatttcgaa tcagggttac agcacgggtca ccttcgacgg gaacccacag 960
tacggtcaea cgccttcgca ccatgcggcg cagtcccca accactcaat caagcatgag 1020
gatcccatgg gccagcaggg ctgcgtgggt ctccgtggcc gcccccggtc 1080
tatggctgcc acaccccac cgacagctgc accggcagcc aggctttgct gctgaggagc 1140
ccctacagca gtgacaattt ataccaaatg acatccagc ttaaatgcat gacctggaat 1200
cagatgaact taggagccac cttaaaggcg tga                                     1233

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<210> 329

<211> 1776

<212> DNA

<213> Homo sapiens

<400> 329

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tttgacacgg atgtactcaa agcgggacgg gcatcctcg tcgatttctg ggcgagatgg 120
tgccgtccgt gcaaaatgat cgcgccgatt ctggatgaaa tcgctgacga atatcagggc 180
aaactgacgg ttgcaaaact gaacatcgat caaaacccgt gcaactgcgc gaaatatggc 240
atccgtggta tcccgactct gctgctgttc aaaaacgggt aagtggcggc aaccaaatgg 300
ggtgcatctg ctaaagggtca gttgaaagag ttccctgcag ctacactggc cggttctggt 360
ttggccata tgacgacatca ccacatcac cactgtctca tcgaaggtcg tctagtctct 420
ggtggcagcg gctcgtgttc cgtggttagc tctggttcgg gggacgacga cgacaaatct 480
agtaggatgg gctccgacgt tctgtagcct aacgcactgc tgccggcagt tccgtccctg 540
ggtggtggtg gtggttgctgc actgcgggtt agcgggtgac cacagtgggc tccggttctg 600
gacttcgacg cgcgcgggtg atccgcatac ggttcctctg gtggtccggc accgcgcggc 660
gcaccgcggc cgcgcgcggc gccgcgcggc cactcctca tcaaacagga accgagctgg 720
ggtggtgacg aaccgcacga agaacagtgc ctgagcgcat tcacgttca ctctccggc 780
cagttcaact gcacagcggg agcctgtctc taaggggcct tccgtcctcc tccgccagc 840
caggcgtcat cgcgcggcgg caggatgttt cctaagcgcc ctaactctgc cagctgctc 900
gagagccagg ccgtattctg caatcagggt tacagcagg tcactctga cgggacggcc 960
agtaacggtc acacgccttc gcaactgcg gcgcagttcc ccaaccactc attcaagcat 1020
gaggaatcca tggggcagca gggctcgtg ggtgagcagc agtaactcgt gccgccccgc 1080
gtctattggt gccaaccccc accgcacagc tgacccggca cgcaggcttt tctgctagg 1140
acgccttaca cagatgacaa ttataccaa atgacatccc agcttgaatg catgacctgg 1200
aatcagatga acttaggagc cacttaaac ggcacacga cagggtacga gcgcataac 1260
cacacaacgc ccatcctctg cggagcccaa tacagaatac acacgcaggc tgtcttca 1320
ggcattcagg atgtgcgacg tgtgcttgga ttagcccgga ctcttgtagc gatggcatct 1380
agaaacaggc agaaacggcc ctctcgtggt gcttaaccag gctgcaataa gagatatctt 1440
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gacttcaagg actgtgaacg aaggtttttt cgttcagacc agcgaagaat acccaaaaag 1560
agacatacag gtgtgaaacc atccagtggt aaaaacttgt agcgaagaat ctcccggtcc 1620
gaccactgta agaccacacac caggactcat acaggtgaaa agcccttcag ctgctcgtgg 1680
ccaagtgtgc agaaaaagtt tgcccggtca gatgaattag tccgccatca caacatgcat 1740
cagagaaaaa tgaccaaaact ccagctggcg ctttga 1776

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<210> 330
<211> 771
<212> DNA
<213> Homo sapiens

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<400> 330
atgcagcatt accaccatca ccacggctcc gacgttcgtg acctgaacgc actgctgcgc 60
cgagtccgt cctcgggtgg ttgtggtggt tgcgcaactgc cggttagcgg tgacgacagc 120
tgccgtccgt tctcggaatt cgcacgcggc ggtgcatccg catacgggtc cctgggtggt 180
cgcgcacggc cgcgcgcacc gccgcgcggc cgcgcgcggc cgcgcgaact ctctcatcaa 240
caggaaacga gctgggtggg tgacagaacc cagcaagaac agtccttagc gcgattcacc 300
gttcaactct cgggcagttt cactggcaca gccggagcct gtcgctacgg gcccttcggt 360
ctctccctcc ccaagcaggc gtcctccggc caggccagga tgtttcttaa cgcgcctcac 420
ctgcaccaag gcctcgagag ccagcccgtt attcgcaatc agggttacag cagggtcacc 480
ttcgacggga cgcccagcta cgttcacacg cctcgcaccc atgcggcgca gttccccaac 540
cactcatcca agcatagagg tcccatgggc cagcagggct cgtcgggtga cggcaggtac 600
tcggtgcgcg ccccggtcta ttgctgccac acccccacgc acagctgcac cgacgacgag 660
gcttctgctg tgaggacggc ctacagcagt gacaatttat accaaatgac atcccgactt 720
gaatgcatac ctgggaatca gatgaacta ggagccactc taaagggtcg a 771

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<210> 331
<211> 567
<212> DNA
<213> Homo sapiens

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<400> 331
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gatgtgcgac gtgtgcctgg agtagccccc actcttgtag ggtcgggcatc tgagaccagt 180
gagaaacgcc ccttcattgt tgcttaccca ggctgcaata agagatatatt taagctgtcc 240
cacttacaga tgcacagcag gaagcacact ggtgagaaac cataccagtg tgacttcaag 300
gactgtgaac gaagggtttt tcgttcagac cagctcaaaa gacaccaag gagacataca 360
ggtgtgaaac cattccagtg taaaacttgt cagcgaaagt tctcccggtc cgaccacctg 420
aagaccacaca ccaggactca tacaggtgaa aagcccttca gctgtcggtg gccaaagtgt 480
cagaaaaagt ttgcccggtc agatgaatta gtccggccatc acaacatgca tcagagaaac 540
atgaccaaac tccagctggc gctttga 567

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<210> 332

<211> 342

<212> PRT

<213> Homo sapiens

<400> 332

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Met Gln His His His His His His Met Ser Asp Lys Ile Ile His Leu
5 10 15
Thr Asp Asp Ser Phe Asp Thr Asp Val Leu Lys Ala Asp Gly Ala Ile
20 25 30
Leu Val Asp Phe Trp Ala Glu Trp Cys Gly Pro Cys Lys Met Ile Ala
35 40 45
Pro Ile Leu Asp Glu Ile Ala Asp Glu Tyr Gln Gly Lys Leu Thr Val
50 55 60
Ala Lys Leu Asn Ile Asp Gln Asn Pro Gly Thr Ala Pro Lys Tyr Gly
65 70 75
Ile Arg Gly Ile Pro Thr Leu Leu Leu Phe Lys Asn Gly Glu Val Ala
85 90 95
Ala Thr Lys Val Gly Ala Leu Ser Lys Gly Gln Leu Lys Glu Phe Leu
100 105 110
Asp Ala Asn Leu Ala Gly Ser Gly Ser Gly His Met Gln His His His
115 120 125
His His His Val Ser Ile Glu Gly Arg Ala Ser Ser Gly Gly Ser Gly
130 135 140
Leu Val Pro Arg Gly Ser Ser Gly Ser Gly Asp Asp Asp Lys Ser
145 150 155
Ser Arg His Ser Thr Gly Tyr Glu Ser Asp Asn His Thr Thr Pro Ile
165 170 175
Leu Cys Gly Ala Gln Tyr Arg Ile His Thr His Gly Val Phe Arg Gly
180 185 190
Ile Gln Asp Val Arg Arg Val Pro Gly Val Ala Pro Thr Leu Val Arg
195 200 205
Ser Ala Ser Glu Thr Ser Glu Lys Arg Pro Phe Met Cys Ala Tyr Pro
210 215 220
Gly Cys Asn Lys Arg Tyr Phe Lys Leu Ser His Leu Gln Met His Ser
225 230 235
Arg Lys His Thr Gly Glu Lys Pro Tyr Gln Cys Asp Phe Lys Asp Cys
245 250 255
Glu Arg Arg Phe Phe Arg Ser Asp Gln Leu Lys Arg His Gln Arg Arg
260 265 270
His Thr Gly Val Lys Pro Phe Gln Cys Lys Thr Cys Gln Arg Lys Phe
275 280 285
Ser Arg Ser Asp His Leu Lys Thr His Thr Arg Thr His Thr Gly Glu
290 295 300
Lys Pro Phe Ser Cys Arg Trp Pro Ser Cys Gln Lys Lys Phe Ala Arg

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305 310 315 320
Ser Asp Glu Leu Val Arg His His Asn Met His Gln Arg Asn Met Thr
 325
Lys Leu Gln Leu Ala Leu 330 335

340

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<210> 333
<211> 410
<212> PRT
<213> Homo sapiens
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[illegible]

Gln Tyr Ser Val Pro Pro Pro Val Tyr Gly Cys His Thr Pro Thr Asp
 355 360 365
 Ser Cys Thr Gly Ser Gln Ala Leu Leu Arg Thr Pro Tyr Ser Ser
 370 375 380
 Asp Asn Leu Tyr Gln Met Thr Ser Gln Leu Glu Cys Met Thr Trp Asn
 385 390 395 400
 Gln Met Asn Leu Gly Ala Thr Leu Lys Gly
 405 410

<210> 334

<211> 591

<212> PRT

<213> Homo sapiens

<400> 334

Met Gln His His His His His Met Ser Asp Lys Ile Ile His Leu
 5 10 15
 Thr Asp Asp Ser Phe Asp Thr Asp Val Leu Lys Ala Asp Gly Ala Ile
 20 25 30
 Leu Val Asp Phe Trp Ala Glu Trp Cys Gly Pro Cys Lys Met Ile Ala
 35 40 45
 Pro Ile Leu Asp Glu Ile Ala Asp Glu Tyr Gln Gly Lys Leu Thr Val
 50 55 60
 Ala Lys Leu Asn Ile Asp Gln Asn Pro Gly Thr Ala Pro Lys Tyr Gly
 65 70 75 80
 Ile Arg Gly Ile Thr Leu Leu Leu Phe Lys Asn Gly Glu Val Ala
 85 90 95
 Ala Thr Lys Val Gly Ala Leu Ser Lys Gly Gln Leu Lys Glu Phe Leu
 100 105 110
 Asp Ala Asn Leu Ala Gly Ser Gly Ser Gly His Met Gln His His His
 115 120 125
 His His His Val Ser Ile Glu Gly Arg Ala Ser Ser Gly Gly Ser Gly
 130 135 140
 Leu Val Pro Arg Gly Ser Ser Gly Ser Gly Asp Asp Asp Lys Ser
 145 150 155 160
 Ser Arg Met Gly Ser Asp Val Arg Asp Leu Asn Ala Leu Leu Pro Ala
 165 170 175
 Val Pro Ser Leu Gly Gly Gly Gly Cys Ala Leu Pro Val Ser Gly
 180 185 190
 Ala Ala Gln Trp Ala Pro Val Leu Asp Phe Ala Pro Pro Gly Ala Ser
 195 200 205
 Ala Tyr Gly Ser Leu Gly Gly Pro Ala Pro Pro Ala Pro Pro Pro
 210 215 220
 Pro Pro Pro Pro Pro Pro His Ser Phe Ile Lys Gln Glu Pro Ser Trp
 225 230 235 240
 Gly Gly Ala Glu Pro His Glu Glu Gln Cys Leu Ser Ala Phe Thr Val
 245 250 255
 His Phe Ser Gly Gln Phe Thr Gly Thr Ala Gly Ala Cys Arg Tyr Gly
 260 265 270
 Pro Phe Gly Pro Pro Pro Pro Ser Gln Ala Ser Ser Gly Gln Ala Arg
 275 280 285
 Met Phe Pro Asn Ala Pro Tyr Leu Pro Ser Cys Leu Glu Ser Gln Pro
 290 295 300
 Ala Ile Arg Asn Gln Gly Tyr Ser Thr Val Thr Phe Asp Gly Thr Pro
 305 310 315 320
 Ser Tyr Gly His Thr Pro Ser His His Ala Gln Phe Pro Asn His
 325 330 335

Ser Phe Lys His Glu Asp Pro Met Gly Gln Gln Gly Ser Leu Gly Glu
 340 345 350
 Gln Gln Tyr Ser Val Pro Pro Pro Val Tyr Gly Cys His Thr Pro Thr
 355 360 365
 Asp Ser Cys Thr Gly Ser Gln Ala Leu Leu Leu Arg Thr Pro Tyr Ser
 370 375 380
 Ser Asp Asn Leu Tyr Gln Met Thr Ser Gln Leu Glu Cys Met Thr Trp
 385 390 395 400
 Asn Gln Met Asn Leu Gly Ala Thr Leu Lys Gly His Ser Thr Gly Tyr
 405 410 415
 Glu Ser Asp Asn His Thr Thr Pro Ile Leu Cys Gly Ala Gln Tyr Arg
 420 425 430
 Ile His Thr His Gly Val Phe Arg Gly Ile Gln Asp Val Arg Arg Val
 435 440 445
 Pro Gly Val Ala Pro Thr Leu Val Arg Ser Ala Ser Glu Thr Ser Glu
 450 455 460
 Lys Arg Pro Phe Met Cys Ala Tyr Pro Gly Cys Asn Lys Arg Tyr Phe
 465 470 475 480
 Lys Leu Ser His Leu Gln Met His Ser Arg Lys His Thr Gly Glu Lys
 485 490 495
 Pro Tyr Gln Cys Asp Phe Lys Asp Cys Glu Arg Arg Phe Arg Ser
 500 505 510
 Asp Gln Leu Lys Arg His Gln Arg Arg His Thr Gly Val Lys Pro Phe
 515 520 525
 Gln Cys Lys Thr Cys Gln Arg Lys Phe Ser Arg Ser Asp His Leu Lys
 530 535 540
 Thr His Thr Arg Thr His Thr Gly Glu Lys Pro Phe Ser Cys Arg Trp
 545 550 555 560
 Pro Ser Cys Gln Lys Lys Phe Ala Arg Ser Asp Glu Leu Val Arg His
 565 570 575
 His Asn Met His Gln Arg Asn Met Thr Lys Leu Gln Leu Ala Leu
 580 585 590

<210> 335

<211> 256

<212> PRT

<213> Homo sapiens

<400> 335

Met Gln His His His His His His Gly Ser Asp Val Arg Asp Leu Asn
 5 10 15
 Ala Leu Leu Pro Ala Val Pro Ser Leu Gly Gly Gly Gly Cys Ala
 20 25 30
 Leu Pro Val Ser Gly Ala Ala Gln Trp Ala Pro Val Leu Asp Phe Ala
 35 40 45
 Pro Pro Gly Ala Ser Ala Tyr Gly Ser Leu Gly Gly Pro Ala Pro Pro
 50 55 60
 Pro Ala Pro Pro Pro Pro Pro Pro Pro His Ser Phe Ile Lys
 65 70 75 80
 Gln Glu Pro Ser Trp Gly Gly Ala Glu Pro His Glu Glu Gln Cys Leu
 85 90 95
 Ser Ala Phe Thr Val His Phe Ser Gly Gln Phe Thr Gly Thr Ala Gly
 100 105 110
 Ala Cys Arg Tyr Gly Pro Phe Gly Pro Pro Pro Ser Gln Ala Ser
 115 120 125
 Ser Gly Gln Ala Arg Met Phe Pro Asn Ala Pro Tyr Leu Pro Ser Cys

130 135 140
 Leu Glu Ser Gln Pro Ala Ile Arg Asn Gln Gly Tyr Ser Thr Val Thr
 145 150 155 160
 Phe Asp Gly Thr Pro Ser Tyr Gly His Thr Pro Ser His His Ala Ala
 165 170 175
 Gln Phe Pro Asn His Ser Phe Lys His Glu Asp Pro Met Gly Gln Gln
 180 185 190
 Gly Ser Leu Gly Glu Gln Gln Tyr Ser Val Pro Pro Val Tyr Gly
 195 200 205
 Cys His Thr Pro Thr Asp Ser Cys Thr Gly Ser Gln Ala Leu Leu Leu
 210 215 220
 Arg Thr Pro Tyr Ser Ser Asp Asn Leu Tyr Gln Met Thr Ser Gln Leu
 225 230 235 240
 Glu Cys Met Thr Trp Asn Gln Met Asn Leu Gly Ala Thr Leu Lys Gly
 245 250 255

<210> 336

<211> 188

<212> PRT

<213> Homo sapiens

<400> 336

Met Gln His His His His His His His Ser Thr Gly Tyr Glu Ser Asp
 5 10 15
 Asn His Thr Thr Pro Ile Leu Cys Gly Ala Gln Tyr Arg Ile His Thr
 20 25 30
 His Gly Val Phe Arg Gly Ile Gln Asp Val Arg Arg Val Pro Gly Val
 35 40 45
 Ala Pro Thr Leu Val Arg Ser Ala Ser Glu Thr Ser Glu Lys Arg Pro
 50 55 60
 Phe Met Cys Ala Tyr Pro Gly Cys Asn Lys Arg Tyr Phe Lys Leu Ser
 65 70 75 80
 His Leu Gln Met His Ser Arg Lys His Thr Gly Glu Lys Pro Tyr Gln
 85 90 95
 Cys Asp Phe Lys Asp Cys Glu Arg Arg Phe Arg Ser Asp Gln Leu
 100 105 110
 Lys Arg His Gln Arg Arg His Thr Gly Val Lys Pro Phe Gln Cys Lys
 115 120 125
 Thr Cys Gln Arg Lys Phe Ser Arg Ser Asp His Leu Lys Thr His Thr
 130 135 140
 Arg Thr His Thr Gly Glu Lys Pro Phe Ser Cys Arg Trp Pro Ser Cys
 145 150 155 160
 Gln Lys Lys Phe Ala Arg Ser Asp Glu Leu Val Arg His His Asn Met
 165 170 175
 His Gln Arg Asn Met Thr Lys Leu Gln Leu Ala Leu
 180 185

<210> 337

<211> 324

<212> DNA

<213> Homo sapiens

<400> 337

atgcagcatc accaccatca ccacgggtcc gacgtgcggg acctgaacgc actgctgccg 60
 gcagttccat cctggggtgg cgggtggaggc tgcgcactgc cggttagcgg tgcagcacag 120
 tgggtctccag ttctggactt cgcaccgcct ggtgcatccg catacgggtc cctgggggtg 180
 ccagcacctc cgcccgcaac gcccccaccg cctccaccgc ccccgcactc cttcatcaaa 240

caggaaccta gctggggtgg tgcagaacgg cacgaagaac agtgccctgag cgcattctga 300
gaattcttga gatattcatc acac 324

<210> 338

<211> 462

<212> DNA

<213> Homo sapiens

<400> 338

atgcagcatc accaccatca ccaccacgaa gaacagtgcc tgagcgcatt caccgttcac 60
ttctccgggc agttcaactgg cacagccgga gctctgcgct acgggccctt cgggtccctc 120
cgccccagcc aggcgtcatc cggccagacc aggatgttcc ctaacgcgcc ctacctgcc 180
agctgcctcg agagccagcc cgtatttcgc aatcagggtt acagcagcgt caccttcgac 240
gggagcgcga gctacgggtca cagccctcgc caccatgcgg cgcagtcccc caaccactca 300
ttcaagcatg aggatcccat gggccagcag ggctcgcctgg gtgagcagca gtactcgggtg 360
cgcccccggg tctatggctg ccaccacccc accgacagct gcacggcgag ccaggctttg 420
ctgctgagga cgccctacag cagtgacaat ttatactgat ga 462

<210> 339

<211> 405

<212> DNA

<213> Homo sapiens

<400> 339

atgcagcatc accaccatca ccaccaggct ttgctgctga ggagcgccta cagcagtgac 60
aattttatac aaatgacatc ccagcttgaa tgcagtacct ggaatcagat gaacttagga 120
gcaaccctta agggccacag cacagggtac accacacaac gcccatcctc 180
tgccggagccc aatacagaat acacacgcac ggtgtcttca gaggcattca ggaatgtcga 240
cgtgtccttg gagttagcccc gactcttcta cggctcggtc ctgagaccag tgagaaacgc 300
cccttcattg gtgcttaccg aggcctgcaat aagagatatt ttaagctgtc ccacttacag 360
atgcacagca ggaagcacac tggtagagaa ccataccagt gatga 405

<210> 340

<211> 339

<212> DNA

<213> Homo sapiens

<400> 340

atgcagcatc accaccatca ccaccacagc aggaagcaca ctgggtgagaa accataccag 60
tgtgacttca aggaactgtga acgaagggtt ttctggtcag accagctcaa aagacaccaa 120
aggagacata cagggttgaa accattccag tgtaaaactt gtgacgcgaa gtctctccgg 180
tccgaccacc tgaagaccca caccaggact catacaggtg aaaaagccctt cagctgtcgg 240
tggccaaagt gtcagaaaat gtttgccggg tcagatgtaa tagtccgcca tcacaacatg 300
catcagagaa acatgaccaa actccagctg gcgctttga 339

<210> 341

<211> 1110

<212> DNA

<213> Homo sapiens

<400> 341

atgcagcatc accaccatca ccaccactcc ttcatacaac aggaaccgag ctgggggtgg 60
gcagaaccgc acgaagaaca gtgcctgagc gcatccaccg ttcactttct cggccagttc 120
actggcacag ccggagcctg tcgctacggg cctctcggtc ctctctcgcc cagccaggcg 180
tcatccggcc aggcaggatg gtttcttaac gcgccctacc tgcccagctg cctcgagagc 240
cagcccgcta ttcgaatca gggttacagc acgggtcacct tcgacgggac gcccaagctac 300


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ggtcacacgc cctcgccacca tgcggcgagc tcccccaacc atcattcaaa gcatgaggat 360
cccatggggc agcaggggctc gctgggtgag cagcagttat cgggtgccgc cccgggtctat 420
ggctgcccaca cccccaccga cagctgcacc ggcagccagg ctttgcgtct gaggacgccc 480
tacagcagtg acaatttata ccaaatgaca tcccagcttg aatgcatgac ctggaatcag 540
atgaacttag gagccacctt aaaggggcac agcacagggt acgagagcga taaccacaca 600
acgcccatcc tctgcggagc ccaatacaga atacacacgc acggtgtctt cagaggcatt 660
caggatgtgc gacgtgtgcc tggagtagcc cgcactcttg tacggtcggc atctgagacc 720
agtgagaaac gcccttccat gtgtgcttac ccaggctgca ataagagata ttttaagctg 780
tcccacttac agatgcacag caggaagcac actggtgaga aaccatacca gtgtgacttc 840
aaggactgtg aacgaaggtt ttttcgttca gaccagctca aaagacacca aaggagacat 900
acagggtgtga aaccattcca gtgtaaaact tgtcagcgaa agttctcccc gtccgaccac 960
ctgaagaccc acaccaggac tcatacaggt gaaaagccct tcagctgtcg gtggcccaagt 1020
tgtcagaaaa agtttgcggc gtcagatgaa ttagtccgcc atcacaacat gcatcagaga 1080
aacatgacca aactccagct ggcgcttga 1110

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<210> 342
 <211> 99
 <212> PRT
 <213> Homo sapiens

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<400> 342
Met Gln His His His His His His Gly Ser Asp Val Arg Asp Leu Asn
                    5              10              15
Ala Leu Leu Pro Ala Val Pro Ser Leu Gly Gly Gly Gly Cys Ala
                20              25              30
Leu Pro Val Ser Gly Ala Ala Gln Trp Ala Pro Val Leu Asp Phe Ala
                35              40              45
Pro Pro Gly Ala Ser Ala Tyr Gly Ser Leu Gly Gly Pro Ala Pro Pro
                50              55              60
Pro Ala Pro Pro Pro Pro Pro Pro Pro Pro His Ser Phe Ile Lys
                65              70              75              80
Gln Glu Pro Ser Trp Gly Gly Ala Glu Pro His Glu Glu Gln Cys Leu
                85              90              95
Ser Ala Phe

```

<210> 343
 <211> 152
 <212> PRT
 <213> Homo sapiens

```

<400> 343
Met Gln His His His His His His His Glu Glu Gln Cys Leu Ser Ala
                    5              10              15
Phe Thr Val His Phe Ser Gly Gln Phe Thr Gly Thr Ala Gly Ala Cys
                20              25              30
Arg Tyr Gly Pro Phe Gly Pro Pro Pro Pro Ser Gln Ala Ser Ser Gly
                35              40              45
Gln Ala Arg Met Phe Pro Asn Ala Pro Tyr Leu Pro Ser Cys Leu Glu
                50              55              60
Ser Gln Pro Ala Ile Arg Asn Gln Gly Tyr Ser Thr Val Thr Phe Asp
                65              70              75              80
Gly Thr Pro Ser Tyr Gly His Thr Pro Ser His His Ala Ala Gln Phe
                85              90              95
Pro Asn His Ser Phe Lys His Glu Asp Pro Met Gly Gln Gln Gly Ser
                100              105              110
Leu Gly Glu Gln Gln Tyr Ser Val Pro Pro Val Tyr Gly Cys His

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      115              120              125
Thr Pro Thr Asp Ser Cys Thr Gly Ser Gln Ala Leu Leu Leu Arg Thr
      130              135              140
Pro Tyr Ser Ser Asp Asn Leu Tyr
145              150

```

<210> 344

<211> 133

<212> PRT

<213> Homo sapiens

<400> 344

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Met Gln His His His His His His Gln Ala Leu Leu Leu Arg Thr Pro
      5              10              15
Tyr Ser Ser Asp Asn Leu Tyr Gln Met Thr Ser Gln Leu Glu Cys Met
      20              25              30
Thr Trp Asn Gln Met Asn Leu Gly Ala Thr Leu Lys Gly His Ser Thr
      35              40              45
Gly Tyr Glu Ser Asp Asn His Thr Thr Pro Ile Leu Cys Gly Ala Gln
      50              55              60
Tyr Arg Ile His Thr His Gly Val Phe Arg Gly Ile Gln Asp Val Arg
      65              70              75
Arg Val Pro Gly Val Ala Pro Thr Leu Val Arg Ser Ala Ser Glu Thr
      85              90              95
Ser Glu Lys Arg Pro Phe Met Cys Ala Tyr Pro Gly Cys Asn Lys Arg
      100             105             110
Tyr Phe Lys Leu Ser His Leu Gln Met His Ser Arg Lys His Thr Gly
      115             120             125
Glu Lys Pro Tyr Gln
130

```

<210> 345

<211> 112

<212> PRT

<213> Homo sapiens

<400> 345

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Met Gln His His His His His His His Ser Arg Lys His Thr Gly Glu
      5              10              15
Lys Pro Tyr Gln Cys Asp Phe Lys Asp Cys Glu Arg Arg Phe Arg
      20              25              30
Ser Asp Gln Leu Lys Arg His Gln Arg Arg His Thr Gly Val Lys Pro
      35              40              45
Phe Gln Cys Lys Thr Cys Gln Arg Lys Phe Ser Arg Ser Asp His Leu
      50              55              60
Lys Thr His Thr Arg Thr His Thr Gly Glu Lys Pro Phe Ser Cys Arg
      65              70              75
Trp Pro Ser Cys Gln Lys Lys Phe Ala Arg Ser Asp Glu Leu Val Arg
      85              90              95
His His Asn Met His Gln Arg Asn Met Thr Lys Leu Gln Leu Ala Leu
      100             105             110

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<210> 346

<211> 369

<212> PRT

<213> Homo sapiens

<400> 346

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Met Gln His His His His His His His Ser Phe Ile Lys Gln Glu Pro
                    5              10              15
Ser Trp Gly Gly Ala Glu Pro His Glu Glu Gln Cys Leu Ser Ala Phe
          20              25              30
Thr Val His Phe Ser Gly Gln Phe Thr Gly Thr Ala Gly Ala Cys Arg
          35              40              45
Tyr Gly Pro Phe Gly Pro Pro Pro Ser Gln Ala Ser Ser Gly Gln
          50              55              60
Ala Arg Met Phe Pro Asn Ala Pro Tyr Leu Pro Ser Cys Leu Glu Ser
          65              70              75
Gln Pro Ala Ile Arg Asn Gln Gly Tyr Ser Thr Val Thr Phe Asp Gly
          85              90              95
Thr Pro Ser Tyr Gly His Thr Pro Ser His His Ala Ala Gln Phe Pro
          100             105             110
Asn His Ser Phe Lys His Glu Asp Pro Met Gly Gln Gln Gly Ser Leu
          115             120             125
Gly Glu Gln Gln Tyr Ser Val Pro Pro Pro Val Tyr Gly Cys His Thr
          130             135             140
Pro Thr Asp Ser Cys Thr Gly Ser Gln Ala Leu Leu Leu Arg Thr Pro
          145             150             155
Tyr Ser Ser Asp Asn Leu Tyr Gln Met Thr Ser Gln Leu Glu Cys Met
          165             170             175
Thr Trp Asn Gln Met Asn Leu Gly Ala Thr Leu Lys Gly His Ser Thr
          180             185             190
Gly Tyr Glu Ser Asp Asn His Thr Thr Pro Ile Leu Cys Gly Ala Gln
          195             200             205
Tyr Arg Ile His Thr His Gly Val Phe Arg Gly Ile Gln Asp Val Arg
          210             215             220
Arg Val Pro Gly Val Ala Pro Thr Leu Val Arg Ser Ala Ser Glu Thr
          225             230             235
Ser Glu Lys Arg Pro Phe Met Cys Ala Tyr Pro Gly Cys Asn Lys Arg
          245             250             255
Tyr Phe Lys Leu Ser His Leu Gln Met His Ser Arg Lys His Thr Gly
          260             265             270
Glu Lys Pro Tyr Gln Cys Asp Phe Lys Asp Cys Glu Arg Arg Phe Phe
          275             280             285
Arg Ser Asp Gln Leu Lys Arg His Gln Arg Arg His Thr Gly Val Lys
          290             295             300
Pro Phe Gln Cys Lys Thr Cys Gln Arg Lys Phe Ser Arg Ser Asp His
          305             310             315
Leu Lys Thr His Thr Arg Thr His Thr Gly Glu Lys Pro Phe Ser Cys
          325             330             335
Arg Trp Pro Ser Cys Gln Lys Lys Phe Ala Arg Ser Asp Glu Leu Val
          340             345             350
Arg His His Asn Met His Gln Arg Asn Met Thr Lys Leu Gln Leu Ala
          355             360             365
Leu

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<210> 347

<211> 21

<212> DNA

<213> Artificial Sequence

<220>

<223> Primer

<400> 347

ggctccgacg tgcgggacct g

21

<210> 348

<211> 30

<212> DNA

<213> Artificial Sequence

<220>

<223> Primer

<400> 348

gaattctcaa agcgccagct ggagtttggt

30

<210> 349

<211> 21

<212> DNA

<213> Artificial Sequence

<220>

<223> Primer

<400> 349

ggctccgacg tgcgggacct g

21

<210> 350

<211> 30

<212> DNA

<213> Artificial Sequence

<220>

<223> Primer

<400> 350

gaattctcaa agcgccagct ggagtttggt

30

<210> 351

<211> 21

<212> DNA

<213> Artificial Sequence

<220>

<223> Primer

<400> 351

cacagcacag ggtacgagag c

21

<210> 352

<211> 30

<212> DNA

<213> Artificial Sequence

<220>

<223> Primer

<400> 352

gaattctcaa agcgccagct ggagtttggg 30

<210> 353
<211> 29
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 353
cacgaagaac agtgctgag cgcattcac 29

<210> 354
<211> 32
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 354
ccggcgaatt catcagtata aattgtcact gc 32

<210> 355
<211> 24
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 355
caggctttgc tgctgaggac gccc 24

<210> 356
<211> 34
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 356
cacggagaat tcactactgg tatggtttct cacc 34

<210> 357
<211> 28
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 357
cacagcagga agcacactgg tgagaaac 28

<210> 358

<211> 30
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 358
ggatatctgc agaattctca aagcgccagc 30

<210> 359
<211> 22
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 359
cactccttca tcaaacagga ac 22

<210> 360
<211> 30
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 360
ggatatctgc agaattctca aagcgccagc 30

<210> 361
<211> 33
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 361
ggttcgcagc tgcgggacct gaacgcactg ctg 33

<210> 362
<211> 40
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 362
ctgcgcgcag cagtgcgttc aggtcccga cgtcggaacc 40

<210> 363
<211> 35
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 363
cggcagttc catccctggg tggcgggtga ggctg 35

<210> 364
<211> 38
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 364
cggcagtgcg cagcctccac cgccaccag ggaaggaa 38

<210> 365
<211> 35
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 365
cgcaactgccg gttagcgggt cagcacagtg ggctc 35

<210> 366
<211> 33
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 366
cagaactgga gcccaactgtg ctgcaccgct aac 33

<210> 367
<211> 38
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 367
cagttctgga cttcgaccg cctgggtgcat ccgcatac 38

<210> 368
<211> 39
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 368
caggggaaccg tatgcggatg caccaggcgg tgcgaagtc 39

<210> 369
<211> 38
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 369
ggttcctgg.gtggtcagc acctccgcc gcaacgcc 38

<210> 370
<211> 38
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 370
ggcggtgggg gcgttcggg cggaggtgct ggaccacc 38

<210> 371
<211> 40
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 371
cccaccgct ccaccgccc cgcactcctt catcaaacag 40

<210> 372
<211> 39
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 372
ctaggttcct gtttgatgaa ggagtgcggg ggcggtgga 39

<210> 373
<211> 38
<212> DNA
<213> Artificial Sequence

<220>
<223> Primer

<400> 373
gaacctagct ggggtggtgc agaaccgcac gaagaaca 38

<210> 374
 <211> 39
 <212> DNA
 <213> Artificial Sequence

 <220>
 <223> Primer

 <400> 374
 ctcaggcact gttcttcgtg cggttctgca ccaccccag 39

 <210> 375
 <211> 32
 <212> DNA
 <213> Artificial Sequence

 <220>
 <223> Primer

 <400> 375
 gtgcctgagc gcattctgag aattctgcag at 32

 <210> 376
 <211> 34
 <212> DNA
 <213> Artificial Sequence

 <220>
 <223> Primer

 <400> 376
 gtgtgatgga tatctgcaga attctcagaa tgcg 34

 <210> 377
 <211> 1292
 <212> DNA
 <213> Homo sapiens

 <220>
 <221> misc_feature
 <222> 253,256,517,518,520,521,522,743,753,754,
 758
 <223> n = A,T,C or G

 <400> 377
 atgggctccg acgttcgtga cctgagcgcg ctgctgccgg cagttccgtc cctgggtgat 60
 ggtgggtggt gcgcactgcc ggttagcggt gcagcacagt gggctccggt tctggacttc 120
 gcaccgccgg gtgcactccg acacggtccc ctgggtggtc cggcgccgcc gtcggcaccg 180
 cgccgcgcgc cgccgcgcgc gccgcactcc ttcattcaaac agggaccgag ctggggtggc 240
 ggggaactgc ackaakaaca gtacctgagc gcgttcaccg ttactctctc cgttcagggt 300
 cactggcagc gccggggcct gtgcgtacgg gccctcggc cccctccgc ccagccaggc 360
 gtcatccggc caggccaggga tgtctcctag cgcgccctgc ctgccagcc gcctcgagag 420
 ccagcccgct acccgcaatc ggggctacag cagcgtcacc ttcagcgggg cgtccggcta 480
 cgttcacagc ccctcgcaacc atgcggcgca gttctcsmar yyactcgtta ggcgtgagga 540
 tccatgggac cagcagggtc cgctgggtga gcagcagtg tcggcgccgc ccccgccgtg 600
 tggccgccac acccccgccg acagctgcgc cggcagccag gctttgctgc tgaggggccc 660

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ctgtgacgacg  gacgggtttat  accaagtgcac  gtcccagctt  gaggcgatgg  cctggagtcac  720
gatgagctctc  gggggccgect  tamcggggcca  cakyacargg  tacgagagcgg  atgatcacac  780
aacgcccggcg  ctctgcggag  cccaatacacg  aatacacacg  cacggtgcct  tcaggggcgt  840
tcagggtgtg  cgccctgtgc  ctggagtagc  cccgactctt  gtacggtcgg  catctgagcg  900
cagtgaaggaa  cgccccctca  tgtgtgctta  ccaaggctgc  aataggaggt  atctgaagct  960
gccccgctta  cacatgcacg  gttaggaagca  cgctggttag  agaccatacc  agtgtgacct  1020
caaggactgt  ggaaggagggt  ttttctgctc  agaccggctc  aaaaagacac  aggggagacc  1080
tacagatgtg  aagccattcc  agcgttaagc  ctgtcagcga  ggggtctccc  ggcccaacca  1140
cctgaagacc  cagcgccagg  ctcatgcagg  tgaaaagccc  cccagctgtc  ggtggtcaga  1200
ttgtcagaga  aagcctgcc  ggtcaagtga  gttggtccg  catcgcgaca  tgcatacaga  1260
gggcatagcc  gaactccagc  tggcgctttg  aa

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<210> 378

<211> 1291

<212> DNA

<213> Homo sapiens

<400> 378

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atggggtccg  acgttcgtga  cctaaacgca  ctgctgccgg  cagttccgtc  cccgggtggt  60
gggtgggtgt  gcgcactgcc  ggttagcggt  gcaaacacagt  ggggtccggt  tctggacttc  120
gtaccgcgg  gtgcgctgt  atcggtgtcc  ctgggtggcc  cgccacggcc  cccagcgccc  180
cgccgctgc  cgcccgccgc  gtccgactcc  ttaccacaa  aggaaccgag  ttgggtggt  240
acagaagcgc  acgcaggaca  gggccggagc  gcactcgctc  ctcaactctc  cgccaggttc  300
actggcacag  ccggagccgt  tcgctacggg  cccttcggtc  ctctcccgcc  cagccagggc  360
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<210> 379

<211> 1281

<212> DNA

<213> Homo sapiens

<400> 379

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gcaccgcgg  ggcgatccgc  atacgatctc  ctgggtggcc  cgccacggcc  gccggcgccc  180
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ccatccggcg  agaccaaggat  gttgccagc  gcgccctatc  ttcgagattg  cctcaggagc  420
cggttcgcta  tccgtagtca  ggggtcgagc  accggcacct  cagcgggggc  cccagctatg  480
gcaccacacc  tcgcacacac  ggcgcagctc  cactactccc  aacatgggg  gcatcatggg  540

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ccagcagggc tcgctgggtg agcagcagta ctcggtgccg ccccggtct atggtcgcca 600
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<210> 380

<211> 3020

<212> DNA

<213> Homo sapiens

<400> 380

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cagcccagcc gcccgggccc cgcgctctcc tcgcgcgcat cctggactgc ctcttgcctg 180
aggacccgcc ttccagtggt gtcccggagc cggcgctctca gcacacgcctc cgcctccggg 240
gagtggtgct acagcagcca gacgacgagc caggtccggga cccggggcgc atctggacca 300
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<210> 381
<211> 1291
<212> DNA
<213> Homo sapiens

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<400> 381
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gcacgcgcgg  gtgcattccg  atacggttcc  cggggtggct  cgcgcacgcc  gcgcgcacgc  180
cgccgcgcgc  cgccgcgcgc  gccgcactcc  ttcatacaac  aggaacgcag  ctggggtggt  240
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tgtcagaaaa  agttttgccg  gtcagatgaa  ttagtcgcgc  atcaaacat  gcatcagaga  1260
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<210> 382
<211> 1491
<212> DNA
<213> Homo sapiens

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<400> 382
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ctgcgcgcag  ttccgtccct  ggggtgtggt  ggtgtgtgct  cactgccggct  tagcgttgca  180
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ggtgtccggc  caccgcgcgc  ggccaccgct  ccgcgcgcgc  cgccgcactc  ctccatcaaa  300
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gtttcaactt  ccggccagtt  cactggcaca  gccggagcct  gtgcctacgg  gcccttcagg  420

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cctcctccgc ccagccaggc gtcattccgc caggccagga tgtttcctaa cgcgcctac 480
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ttgatcccca ttgctgtggg cgggtcccctg gcagggtcgg tcctcatcgt cctcattgcc 1440
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<210> 383

<211> 1251

<212> DNA

<213> Homo sapiens

<400> 383

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ataatggcca actttctctg tgccttctca gtgaactacg acaccaagag tggcccaag 180
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ataactgaca tcagggcgaga tatagataaa aatatcagat gtgttagtgc caccagagtc 480
cacatgaaca acgtgaccgt aacgctccat gatgccacca tccaggcgta cctttccaac 540
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acgctgatcc ccatcgctgt ggtgtgtgccc ctggcggggc tggctctcat gctcctcact 1200
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<210> 384

<211> 228

<212> DNA

<213> Homo sapiens

<400> 384

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gacaccatcg agaattgc aa ggcaagatc caagataagg aaggcatctc tctcgatcag 120

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caagaggttga	tctttgcccg	aaaacagctg	gaagatgggtc	gtaccctgtc	tgactacaac	180
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<210> 385

<211> 1515

<212> DNA

<213> Homo sapiens

<400> 385

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caagaggtca	tctttgcagg	caagcagcta	gaagatggcc	gcactcttcc	tgactacaac	180
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<210> 386

<211> 648

<212> DNA

<213> Homo sapiens

<400> 386

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cgctacgggc	cccttcggtcc	tctctcgccc	agccaggcgt	catccggcca	ggccaggatg	180
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aagggtcaca	gcacagggtg	cgagagcgat	aaccacacaa	cgccatcct	ctcggaagcc	600
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<210> 387

<211> 1089

<212> DNA

<213> Homo sapiens

<400> 387

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caaatgacat cccagcttga atgcatgacc tggaaacaga tgaacttagg agccacctta 540
aaggggcaca gcacagggta cgagagcgat aaccacacaa cgcccatcct ctgcgggagcc 600
caatacagaa tacacacgca cgggtgtctt agaggcattc aggatgtgag acgtgtgcct 660
ggagtagccc cgactcttgt acggtcgcca tctgagacca gtgagaaacg ccccttcatg 720
tgtgtctacc cagcgtgcaa taagagatat tttagctgt cccacttaca gatgcacagc 780
aggaagcaca ctggtgagaa accataccag tgtgacttca agactgtgga acgaagggtt 840
tttcgttcag accagctcaa aagacaccaa aggagacata caggtgtgaa accattccag 900
tgtaaaactt gtcagcgaaa gttctccggg tccgaccacc tgaagaccca caccaggact 960
catcacgggtg aaaagccctt cagctgtcgg tggccaaagt gtcagaaaaa gtttgcggcg 1020
tcagatgaat tagtccgcca tcacaacatg catcagagaa acatgaccaa actccagctg 1080
gcgctttga
1089

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<210> 388

<211> 1035

<212> DNA

<213> Homo sapiens

<400> 388

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atgacggccg cgtccgataa cttccagctg tcccagggtg ggacaggatt cgccattccg 60
atcggggcagg cgaatggcgat cgcggggcag atcaagcttc ccaccgttca tatcgggctc 120
accgcttccc tcggcttggg tgttgtcgac aacaacggca acggcgacg agtccaacgc 180
gtggctcggga gcgctccggc ggcaagtctc ggcatctcca ccggcgagct gatcaccgag 240
gtcagcaggc ctccgatcaa ctccggcacc gcgatggcgg acgcgtctaa cgggcatacat 300
cccggtagcg tcactctcgg gacctggcaa accaagtcgg cggcgacgag tacagggaaac 360
gtgacatagg ccgaggggacc cccggccgaa ttccactcct tcatcaaaac ggaaccggagc 420
tggggtggtg cagaagaacga cgaagaacag ctctgagcgt ccttcacgtt tcaacttctcc 480
ggccagttca ctggcacagc cggagcctgt cgtctacggg ccttcggttc tctctcgccc 540
agccaggcgt catccggcca ggccaggatg ttctctaag ccctctacct cccagctgcg 600
ctcgagagcc agcccgtat tcgcaatcag ggttacagca cgttcacctt cgacgggagc 660
cccagctacg gtcacacgcc ctccgaccat cgcggcgagc tcccacaacca ctcatccaag 720
catgagatgc ccatgggcca gcagggtctg ctgggtgagc agcagtactc ggtgcgccc 780
ccggtctatg gctgccacac ccccaccgag agctgcaccc gtcgccaggg ttgtgctgtg 840
aggaacccct acagcagtga caatttatac caaatgacat cccagcttga atgcatgacc 900
tggaaacaga tgaacttagg agccacctta aagggccaca gcacagggta cgagagcgat 960
aaccacacaa cgcccatcct ctgcggagcc caatacagaa tacacacgca cgggtgtctt 1020
agaggcatc agtga
1035

```

<210> 389

<211> 1263

<212> DNA

<213> Homo sapiens

<400> 389

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atgacggccg cgtccgataa cttccagctg tcccagggtg ggacaggatt cgccattccg 60
atcggggcagg cgaatggcgat cgcggggcag atcaagcttc ccaccgttca tatcgggctc 120
accgcttccc tcggcttggg tgttgtcgac aacaacggca acggcgacg agtccaacgc 180

```

```

gtgggtcggga gcgctccggc ggcaagtctc ggcattctcca cgggcgacgt gatcaccgcg 240
gtcgacggcg ctccgatcaa ctgggccacc gcgatggcgg acgcgcctaa cgggcattcat 300
cccggtgacg tcatctcggt gacctggcaa accagtcctg gcggcacggt tacagggaac 360
gtgacatttg ccgaggggacc cccggccgaa ttcccgctgg tgcgcgcggg cagcccgatg 420
ggctccgacg ttccggacct gaacgcactg ctgcgcggcg ttccgtccct gggtgggtgt 480
gtggtgtgcg cactgcgggt tagcgggtgca gcacagtggg ctccggttct ggacttcgca 540
ccgcggggtg catccgcata cggttccctg ggtggtccgg caccgcgcgg gccaccgcgg 600
ccgcgcgcgc ccgcgcgcgc gcactccttc atcaaacagg aaccgagctg ggggtgtgca 660
gaaccgcacg aagaacagtg cctgagcgca ttcaaccgtt acttctccgg ccagttcaact 720
ggcacagccg gagcctgtcg ctacggggccc ttccgtcttc ctccgccag ccaggcgcta 780
tccggccagg ccaggatgtt tcttaacgcg cctacactgc ccagctgcct cgagagcgcc 840
cccgctattc gcaatcaggg ttacagcagc gtcaccttcg acgggaagcc cagctacggg 900
cacacgcccc cgaccatgc ggcgagttc cccaaccact cattcaagca tgaggatccc 960
atggggcagg agggctcgct ggggtgagcag cagtactcgg tgcgcgcccc ggtctatggc 1020
tgccacaccc ccaccgacag ctgcaccggc agccaggctt tgctgctgag gacgcctac 1080
agcagtgaca atttatacca aatgacatcc cagcttgaat gcatgacctg gaatcagatg 1140
aacttaggag ccaccttaaa gggccacagc acagggtagc agagcgataa ccacacaacg 1200
cccatcctct gcggagccca atacagaata cacacgcacg gtgtcttcag aggcattcag 1260
tga 1263

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<210> 390

<211> 1707

<212> DNA

<213> Homo sapiens

<400> 390

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atgacggccc cgctccgataa ctccagctg tccagggtg ggcaggaggt gcgcattccg 60
atcggggcagg cgatggcgat cgggggcccag atcaagcttc ccaccgttca tatcgggctc 120
accgccttcc tcggcttggg tgttctgacg jacaacggca acggcgacg agtccaacgc 180
gtggtcggga cgctccggcg ggcaagtctc ggcattctcca cgggcgacgt gatcaccggc 240
gtcgacggcg ctccgatcaa ctgggccacc gcgatggcgg acgcgcctaa cgggcattcat 300
cccggtgacg tcatctcggt gacctggcaa accaagtctg gcggcacggt tacagggaac 360
gtgacatttg ccgaggggacc cccggccgaa ttcccgctgg tgcgcgcggg cagcccgatg 420
ggctccgacg ttccggacct gaacgcactg ctgcgcggcg ttccgtccct gggtgtgtgt 480
gtggtgtgcg cactgcgggt tagcgggtgca gcacagtggg ctccggttct ggacttcgca 540
ccgcggggtg catccgcata cggttccctg ggtggtccgg caccgcgcgg gccaccgcgg 600
ccgcgcgcgc ccgcgcgcgc gcactccttc atcaaacagg aaccgagctg ggggtgtgca 660
gaaccgcacg aagaacagtg cctgagcgca ttcaaccgtt acttctccgg ccagttcaact 720
ggcacagccg gagcctgtcg ctacggggccc ttccgtcttc ctccgccag ccaggcgcta 780
tccggccagg ccaggatgtt tcttaacgcg cctacactgc ccagctgcct cgagagcgcc 840
cccgctattc gcaatcaggg ttacagcagc gtcaccttcg acgggaagcc cagctacggg 900
cacacgcccc cgaccatgc ggcgagttc cccaaccact cattcaagca tgaggatccc 960
atggggcagg agggctcgct ggggtgagcag cagtactcgg tgcgcgcccc ggtctatggc 1020
tgccacaccc ccaccgacag ctgcaccggc agccaggctt tgctgctgag gacgcctac 1080
agcagtgaca atttatacca aatgacatcc cagcttgaat gcatgacctg gaatcagatg 1140
aacttaggag ccaccttaaa gggccacagc acagggtagc agagcgataa ccacacaacg 1200
cccatcctct gcggagccca atacagaata cacacgcacg gtgtcttcag aggcattcag 1260
gatgtgcgac gctgtcgctg agtagccccg actcttgtag ggtcggcacc tgagaccagt 1320
gagaaacgcc ccttcatgtg tcttacccca ggtgcaata agagatattt taagctgtcc 1380
cacttcacaga tgcacagcag gaagcacact ggtgagaaac cattaccagt tgacttcaag 1440
gactgtgaac gaaggttttt tctgttcagc cagctcaaaa gacacaaaag gagacataca 1500
ggtgtgaaac ctctccagtg taaaacttgt cagcgaaagt tctcccgctg gcaccacctg 1560
aagaccacac ccaggactca tacaggtgaa aagcccttca gctgtcgggt gccaaagtgt 1620
cagaaaaagt ttgccgggtc agatgaatta tccggccatc acaacatgca tcagagaaac 1680
atgaccacaac tccagctggc gctttga 1707

```

<210> 391

<211> 344

<212> PRT

<213> Homo sapiens

<400> 391

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Met Thr Ala Ala Ser Asp Asn Phe Gln Leu Ser Gln Gly Gly Gln Gly
      5              10              15

Phe Ala Ile Pro Ile Gly Gln Ala Met Ala Ile Ala Gly Gln Ile Lys
      20              25              30

Leu Pro Thr Val His Ile Gly Pro Thr Ala Phe Leu Gly Leu Gly Val
      35              40              45

Val Asp Asn Asn Gly Asn Gly Ala Arg Val Gln Arg Val Val Gly Ser
      50              55              60

Ala Pro Ala Ala Ser Leu Gly Ile Ser Thr Gly Asp Val Ile Thr Ala
      65              70              75              80

Val Asp Gly Ala Pro Ile Asn Ser Ala Thr Ala Met Ala Asp Ala Leu
      85              90              95

Asn Gly His His Pro Gly Asp Val Ile Ser Val Thr Trp Gln Thr Lys
      100             105             110

Ser Gly Gly Thr Arg Thr Gly Asn Val Thr Leu Ala Glu Gly Pro Pro
      115             120             125

Ala Glu Phe His Ser Phe Ile Lys Gln Glu Pro Ser Trp Gly Gly Ala
      130             135             140

Glu Pro His Glu Glu Gln Cys Leu Ser Ala Phe Thr Val His Phe Ser
      145             150             155             160

Gly Gln Phe Thr Gly Thr Ala Gly Ala Cys Arg Tyr Gly Pro Phe Gly
      165             170             175

Pro Pro Pro Pro Ser Gln Ala Ser Ser Gly Gln Ala Arg Met Phe Pro
      180             185             190

Asn Ala Pro Tyr Leu Pro Ser Cys Leu Glu Ser Gln Pro Ala Ile Arg
      195             200             205

Asn Gln Gly Tyr Ser Thr Val Thr Phe Asp Gly Thr Pro Ser Tyr Gly
      210             215             220

His Thr Pro Ser His His Ala Ala Gln Phe Pro Asn His Ser Phe Lys
      225             230             235             240

His Glu Asp Pro Met Gly Gln Gln Gly Ser Leu Gly Glu Gln Gln Tyr
      245             250             255

Ser Val Pro Pro Pro Val Tyr Gly Cys His Thr Pro Thr Asp Ser Cys
      260             265             270

Thr Gly Ser Gln Ala Leu Leu Leu Arg Thr Pro Tyr Ser Ser Asp Asn
      275             280             285

```

Leu Tyr Gln Met Thr Ser Gln Leu Glu Cys Met Thr Trp Asn Gln Met
290 295 300

Asn Leu Gly Ala Thr Leu Lys Gly His Ser Thr Gly Tyr Glu Ser Asp
305 310 315 320

Asn His Thr Thr Pro Ile Leu Cys Gly Ala Gln Tyr Arg Ile His Thr
325 330 335

His Gly Val Phe Arg Gly Ile Gln
340

<210> 392

<211> 568

<212> PRT

<213> Homo sapiens

<400> 392

Met Thr Ala Ala Ser Asp Asn Phe Gln Leu Ser Gln Gly Gly Gln Gly
5 10 15

Phe Ala Ile Pro Ile Gly Gln Ala Met Ala Ile Ala Gly Gln Ile Lys
20 25 30

Leu Pro Thr Val His Ile Gly Pro Thr Ala Phe Leu Gly Leu Gly Val
35 40 45

Val Asp Asn Asn Gly Asn Gly Ala Arg Val Gln Arg Val Val Gly Ser
50 55 60

Ala Pro Ala Ala Ser Leu Gly Ile Ser Thr Gly Asp Val Ile Thr Ala
65 70 75 80

Val Asp Gly Ala Pro Ile Asn Ser Ala Thr Ala Met Ala Asp Ala Leu
85 90 95

Asn Gly His His Pro Gly Asp Val Ile Ser Val Thr Trp Gln Thr Lys
100 105 110

Ser Gly Gly Thr Arg Thr Gly Asn Val Thr Leu Ala Glu Gly Pro Pro
115 120 125

Ala Glu Phe Pro Leu Val Pro Arg Gly Ser Pro Met Gly Ser Asp Val
130 135 140

Arg Asp Leu Asn Ala Leu Leu Pro Ala Val Pro Ser Leu Gly Gly Gly
145 150 155 160

Gly Gly Cys Ala Leu Pro Val Ser Gly Ala Ala Gln Trp Ala Pro Val
165 170 175

Leu Asp Phe Ala Pro Pro Gly Ala Ser Ala Tyr Gly Ser Leu Gly Gly
180 185 190

Pro Ala Pro Pro Pro Ala Pro Pro Pro Pro Pro Pro Pro Pro His
195 200 205

Ser Phe Ile Lys Gln Glu Pro Ser Trp Gly Gly Ala Glu Pro His Glu
 210 215 220
 Glu Gln Cys Leu Ser Ala Phe Thr Val His Phe Ser Gly Gln Phe Thr
 225 230 240
 Gly Thr Ala Gly Ala Cys Arg Tyr Gly Pro Phe Gly Pro Pro Pro Pro
 245 250 255
 Ser Gln Ala Ser Ser Gly Gln Ala Arg Met Phe Pro Asn Ala Pro Tyr
 260 265 270
 Leu Pro Ser Cys Leu Glu Ser Gln Pro Ala Ile Arg Asn Gln Gly Tyr
 275 280 285
 Ser Thr Val Thr Phe Asp Gly Thr Pro Ser Tyr Gly His Thr Pro Ser
 290 295 300
 His His Ala Ala Gln Phe Pro Asn His Ser Phe Lys His Glu Asp Pro
 305 310 315 320
 Met Gly Gln Gln Gly Ser Leu Gly Glu Gln Gln Tyr Ser Val Pro Pro
 325 330 335
 Pro Val Tyr Gly Cys His Thr Pro Thr Asp Ser Cys Thr Gly Ser Gln
 340 345 350
 Ala Leu Leu Leu Arg Thr Pro Tyr Ser Ser Asp Asn Leu Tyr Gln Met
 355 360 365
 Thr Ser Gln Leu Glu Cys Met Thr Trp Asn Gln Met Asn Leu Gly Ala
 370 375 380
 Thr Leu Lys Gly His Ser Thr Gly Tyr Glu Ser Asp Asn His Thr Thr
 385 390 395 400
 Pro Ile Leu Cys Gly Ala Gln Tyr Arg Ile His Thr His Gly Val Phe
 405 410 415
 Arg Gly Ile Gln Asp Val Arg Arg Val Pro Gly Val Ala Pro Thr Leu
 420 425 430
 Val Arg Ser Ala Ser Glu Thr Ser Glu Lys Arg Pro Phe Met Cys Ala
 435 440 445
 Tyr Pro Gly Cys Asn Lys Arg Tyr Phe Lys Leu Ser His Leu Gln Met
 450 455 460
 His Ser Arg Lys His Thr Gly Glu Lys Pro Tyr Gln Cys Asp Phe Lys
 465 470 475 480
 Asp Cys Glu Arg Arg Phe Phe Arg Ser Asp Gln Leu Lys Arg His Gln
 485 490 495
 Arg Arg His Thr Gly Val Lys Pro Phe Gln Cys Lys Thr Cys Gln Arg
 500 505 510
 Lys Phe Ser Arg Ser Asp His Leu Lys Thr His Thr Arg Thr His Thr

515						520						525					
Gly	Glu	Lys	Pro	Phe	Ser	Cys	Arg	Trp	Pro	Ser	Cys	Gln	Lys	Lys	Phe		
530						535						540					
Ala	Arg	Ser	Asp	Glu	Leu	Val	Arg	His	His	Asn	Met	His	Gln	Arg	Asn		
545						550				555		560					
Met	Thr	Lys	Leu	Gln	Leu	Ala	Leu										
565																	

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<210> 393
<211> 420
<212> PRT
<213> Homo sapiens
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400> 393																	
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Phe	Ala	Ile	Pro	Ile	Gly	Gln	Ala	Met	Ala	Ile	Ala	Gly	Gln	Ile	Lys		
			20					25					30				
Leu	Pro	Thr	Val	His	Ile	Gly	Pro	Thr	Ala	Phe	Leu	Gly	Leu	Gly	Val		
		35					40					45					
Val	Asp	Asn	Asn	Gly	Asn	Gly	Ala	Arg	Val	Gln	Arg	Val	Val	Gly	Ser		
		50				55					60						
Ala	Pro	Ala	Ala	Ser	Leu	Gly	Ile	Ser	Thr	Gly	Asp	Val	Ile	Thr	Ala		
		65			70					75					80		
Val	Asp	Gly	Ala	Pro	Ile	Asn	Ser	Ala	Thr	Ala	Met	Ala	Asp	Ala	Leu		
				85					90					95			
Asn	Gly	His	His	Pro	Gly	Asp	Val	Ile	Ser	Val	Thr	Trp	Gln	Thr	Lys		
			100					105					110				
Ser	Gly	Gly	Thr	Arg	Thr	Gly	Asn	Val	Thr	Leu	Ala	Glu	Gly	Pro	Pro		
			115				120					125					
Ala	Glu	Phe	Pro	Leu	Val	Pro	Arg	Gly	Ser	Pro	Met	Gly	Ser	Asp	Val		
		130				135					140						
Arg	Asp	Leu	Asn	Ala	Leu	Leu	Pro	Ala	Val	Pro	Ser	Leu	Gly	Gly	Gly		
		145			150					155				160			
Gly	Gly	Cys	Ala	Leu	Pro	Val	Ser	Gly	Ala	Ala	Gln	Trp	Ala	Pro	Val		
			165					170					175				
Leu	Asp	Phe	Ala	Pro	Pro	Gly	Ala	Ser	Ala	Tyr	Gly	Ser	Leu	Gly	Gly		
			180					185					190				
Pro	Ala	Pro	Pro	Pro	Ala	Pro	Pro	Pro	Pro	Pro	Pro	Pro	Pro	Pro	His		
		195				200						205					
Ser	Phe	Ile	Lys	Gln	Glu	Pro	Ser	Trp	Glv	Glv	Ala	Glu	Pro	His	Glu		

	210						215						220					
Glu	Gln	Cys	Leu	Ser	Ala	Phe	Thr	Val	His	Phe	Ser	Gly	Gln	Phe	Thr			
225					230					235					240			
Gly	Thr	Ala	Gly	Ala	Cys	Arg	Tyr	Gly	Pro	Phe	Gly	Pro	Pro	Pro	Pro			
				245					250					255				
Ser	Gln	Ala	Ser	Ser	Gly	Gln	Ala	Arg	Met	Phe	Pro	Asn	Ala	Pro	Tyr			
			260					265					270					
Leu	Pro	Ser	Cys	Leu	Glu	Ser	Gln	Pro	Ala	Ile	Arg	Asn	Gln	Gly	Tyr			
			275				280					285						
Ser	Thr	Val	Thr	Phe	Asp	Gly	Thr	Pro	Ser	Tyr	Gly	His	Thr	Pro	Ser			
			290			295					300							
His	His	Ala	Ala	Gln	Phe	Pro	Asn	His	Ser	Phe	Lys	His	Glu	Asp	Pro			
305					310					315					320			
Met	Gly	Gln	Gln	Gly	Ser	Leu	Gly	Glu	Gln	Gln	Tyr	Ser	Val	Pro	Pro			
				325					330					335				
Pro	Val	Tyr	Gly	Cys	His	Thr	Pro	Thr	Asp	Ser	Cys	Thr	Gly	Ser	Gln			
			340					345					350					
Ala	Leu	Leu	Leu	Arg	Thr	Pro	Tyr	Ser	Ser	Asp	Asn	Leu	Tyr	Gln	Met			
		355					360					365						
Thr	Ser	Gln	Leu	Glu	Cys	Met	Thr	Trp	Asn	Gln	Met	Asn	Leu	Gly	Ala			
						375					380							
Thr	Leu	Lys	Gly	His	Ser	Thr	Gly	Tyr	Glu	Ser	Asp	Asn	His	Thr	Thr			
385					390					395					400			
Pro	Ile	Leu	Cys	Gly	Ala	Gln	Tyr	Arg	Ile	His	Thr	His	Gly	Val	Phe			
				405					410					415				
Arg	Gly	Ile	Gln															
			420															
<210> 394																		
<211> 362																		
<212> PRT																		
<213> Homo sapiens																		
<400> 394																		
Met	His	Ser	Phe	Ile	Lys	Gln	Glu	Pro	Ser	Trp	Gly	Gly	Ala	Glu	Pro			
				5					10					15				
His	Glu	Glu	Gln	Cys	Leu	Ser	Ala	Phe	Thr	Val	His	Phe	Ser	Gly	Gln			
			20					25					30					
Phe	Thr	Gly	Thr	Ala	Gly	Ala	Cys	Arg	Tyr	Gly	Pro	Phe	Gly	Pro	Pro			
			35				40					45						
Pro	Pro	Ser	Gln	Ala	Ser	Ser	Gly	Gln	Ala	Arg	Met	Phe	Pro	Asn	Ala			

50	55	60
Pro Tyr Leu Pro Ser Cys	Leu Glu Ser Gln	Pro Ala Ile Arg Asn Gln
65	70	75
80		
Gly Tyr Ser Thr Val Thr	Phe Asp Gly Thr	Pro Ser Tyr Gly His Thr
85	90	95
Pro Ser His His Ala Ala	Gln Phe Pro Asn His	Ser Phe Lys His Glu
100	105	110
Asp Pro Met Gly Gln Gln	Gly Ser Leu Gly Glu	Gln Gln Tyr Ser Val
115	120	125
Pro Pro Pro Val Tyr Gly	Cys His Thr Pro Thr	Asp Ser Cys Thr Gly
130	135	140
Ser Gln Ala Leu Leu Leu	Arg Thr Pro Tyr Ser	Ser Asp Asn Leu Tyr
145	150	155
160		
Gln Met Thr Ser Gln Leu	Glu Cys Met Thr Trp	Asn Gln Met Asn Leu
165	170	175
Gly Ala Thr Leu Lys Gly	His Ser Thr Gly Tyr	Glu Ser Asp Asn His
180	185	190
Thr Thr Pro Ile Leu Cys	Gly Ala Gln Tyr Arg	Ile His Thr His Gly
195	200	205
Val Phe Arg Gly Ile Gln	Asp Val Arg Arg Val	Pro Gly Val Ala Pro
210	215	220
Thr Leu Val Arg Ser Ala	Ser Glu Thr Ser Glu	Lys Arg Pro Phe Met
225	230	235
240		
Cys Ala Tyr Pro Gly Cys	Asn Lys Arg Tyr Phe	Lys Leu Ser His Leu
245	250	255
Gln Met His Ser Arg Lys	His Thr Gly Glu Lys	Pro Tyr Gln Cys Asp
260	265	270
Phe Lys Asp Cys Glu Arg	Arg Phe Phe Arg Ser	Asp Gln Leu Lys Arg
275	280	285
His Gln Arg Arg His Thr	Gly Val Lys Pro Phe	Gln Cys Lys Thr Cys
290	295	300
Gln Arg Lys Phe Ser Arg	Ser Asp His Leu Lys	Thr His Thr Arg Thr
305	310	315
320		
His Thr Gly Glu Lys Pro	Phe Ser Cys Arg Trp	Pro Ser Cys Gln Lys
325	330	335
Lys Phe Ala Arg Ser Asp	Glu Leu Val Arg His	His Asn Met His Gln
340	345	350
Arg Asn Met Thr Lys Leu	Gln Leu Ala Leu	
355	360	

<210> 395

<211> 214

<212> PRT

<213> Homo sapiens

<400> 395

[illegible]

<210> 396

<211> 30

<212> DNA

<213> Artificial Sequence

<220>

<223> PCR primer

<400> 396
gacgaaagca tatgcactcc ttcacaaac 30

<210> 397
<211> 31
<212> DNA
<213> Artificial Sequence

<220>
<223> PCR primer

<400> 397
cgcgtagaatt catcactgaa tgcctctgaa g 31

<210> 398
<211> 31
<212> DNA
<213> Artificial Sequence

<220>
<223> PCR primer

<400> 398
cgataagcat atgacggccg cgtccgataa c 31

<210> 399
<211> 31
<212> DNA
<213> Artificial Sequence

<220>
<223> PCR primer

<400> 399
cgcgtagaatt catcactgaa tgcctctgaa g 31

<210> 400
<211> 31
<212> DNA
<213> Artificial Sequence

<220>
<223> PCR primer

<400> 400
cgataagcat atgacggccg cgtccgataa c 31

<210> 401
<211> 28
<212> DNA
<213> Artificial Sequence

<220>
<223> PCR primer

<400> 401

gtctgcagcg gccgctcaaa gcgccagc

28

<210> 402

<211> 30

<212> DNA

<213> Artificial Sequence

<220>

<223> PCR primer

<400> 402

gacgaaagca tatgactcc ttcataaac

30

<210> 403

<211> 28

<212> DNA

<213> Artificial Sequence

<220>

<223> PCR primer

<400> 403

gtctgcagcg gccgctcaaa gcgccagc

28

<210> 404

<211> 449

<212> PRT

<213> Homo sapiens

<400> 404

Met Gly Ser Asp Val Arg Asp Leu Asn Ala Leu Leu Pro Ala Val Pro
 1 5 10 15
 Ser Leu Gly Gly Gly Gly Cys Ala Leu Pro Val Ser Gly Ala Ala
 20 25 30
 Gln Trp Ala Pro Val Leu Asp Phe Ala Pro Pro Gly Ala Ser Ala Tyr
 35 40 45
 Gly Ser Leu Gly Gly Pro Ala Pro Pro Ala Pro Pro Pro Pro
 50 55 60
 Pro Pro Pro Pro His Ser Phe Ile Lys Gln Glu Pro Ser Trp Gly Gly
 65 70 75 80
 Ala Glu Pro His Glu Glu Gln Cys Leu Ser Ala Phe Thr Val His Phe
 85 90 95
 Ser Gly Gln Phe Thr Gly Thr Ala Gly Ala Cys Arg Tyr Gly Pro Phe
 100 105 110
 Gly Pro Pro Pro Pro Ser Gln Ala Ser Ser Gly Gln Ala Arg Met Phe
 115 120 125
 Pro Asn Ala Pro Tyr Leu Pro Ser Cys Leu Glu Ser Gln Pro Ala Ile
 130 135 140
 Arg Asn Gln Gly Tyr Ser Thr Val Thr Phe Asp Gly Thr Pro Ser Tyr
 145 150 155 160
 Gly His Thr Pro Ser His His Ala Ala Gln Phe Pro Asn His Ser Phe
 165 170 175
 Lys His Glu Asp Pro Met Gly Gln Gln Gly Ser Leu Gly Glu Gln Gln
 180 185 190
 Tyr Ser Val Pro Pro Pro Val Tyr Gly Cys His Thr Pro Thr Asp Ser
 195 200 205
 Cys Thr Gly Ser Gln Ala Leu Leu Arg Thr Pro Tyr Ser Ser Asp

210 215 220
 Asn Leu Tyr Gln Met Thr Ser Gln Leu Glu Cys Met Thr Trp Asn Gln
 225 230 235 240
 Met Asn Leu Gly Ala Thr Leu Lys Gly Val Ala Ala Gly Ser Ser Ser
 245 250 255
 Ser Val Lys Trp Thr Glu Gly Gln Ser Asn His Ser Thr Gly Tyr Glu
 260 265 270
 Ser Asp Asn His Thr Thr Pro Ile Leu Cys Gly Ala Gln Tyr Arg Ile
 275 280 285
 His Thr His Gly Val Phe Arg Gly Ile Gln Asp Val Arg Arg Val Pro
 290 295 300
 Gly Val Ala Pro Thr Leu Val Arg Ser Ala Ser Glu Thr Ser Glu Lys
 305 310 315 320
 Arg Pro Phe Met Cys Ala Tyr Pro Gly Cys Asn Lys Arg Tyr Phe Lys
 325 330 335
 Leu Ser His Leu Gln Met His Ser Arg Lys His Thr Gly Glu Lys Pro
 340 345 350
 Tyr Gln Cys Asp Phe Lys Asp Cys Glu Arg Arg Phe Ser Arg Ser Asp
 355 360 365
 Gln Leu Lys Arg His Gln Arg Arg His Thr Gly Val Lys Pro Phe Gln
 370 375 380
 Cys Lys Thr Cys Gln Arg Lys Phe Ser Arg Ser Asp His Leu Lys Thr
 385 390 395 400
 His Thr Arg Thr His Thr Gly Lys Thr Ser Glu Lys Pro Phe Ser Cys
 405 410 415
 Arg Trp Pro Ser Cys Gln Lys Lys Phe Ala Arg Ser Asp Glu Leu Val
 420 425 430
 Arg His His Asn Met His Gln Arg Asn Met Thr Lys Leu Gln Leu Ala
 435 440 445
 Leu

<210> 405

<211> 428

<212> PRT

<213> Homo sapiens

<400> 405

Met Gly Ser Asp Val Arg Asp Leu Asn Ala Leu Leu Pro Ala Val Pro
 1 5 10 15
 Ser Pro Gly Gly Gly Gly Cys Ala Leu Pro Val Ser Gly Ala Thr
 20 25 30
 Gln Trp Ala Pro Val Leu Asp Phe Val Pro Pro Gly Ala Pro Val Cys
 35 40 45
 Gly Ser Leu Gly Gly Pro Ala Pro Pro Ala Pro Pro Pro Leu Pro
 50 55 60
 Pro Pro Pro Ser His Ser Phe Thr Lys Gln Glu Pro Ser Trp Gly Gly
 65 70 75 80
 Thr Glu Pro His Ala Gly Gln Gly Arg Ser Ala Leu Val Ala His Ser
 85 90 95
 Ser Gly Gln Phe Thr Gly Thr Ala Gly Ala Cys Arg Tyr Gly Pro Phe
 100 105 110
 Gly Pro Pro Pro Ser Gln Ala Ser Ser Gly Gln Ala Arg Met Phe
 115 120 125
 Pro Asn Ala Pro Tyr Leu Pro Ser Cys Leu Glu Ser Gln Pro Ala Ile
 130 135 140
 Arg Asn Gln Gly Tyr Ser Thr Val Thr Phe Asp Gly Thr Pro Ser Tyr

145 150 155 160
 Gly His Thr Pro Ser His His Ala Ala Gln Phe Pro Asn His Ser Ser
 165 170 175
 Lys His Glu Asp Pro Met Gly Gln Gln Gly Ser Pro Gly Glu Gln Gln
 180 185
 Tyr Ser Ala Pro Pro Pro Val Cys Gly Cys Arg Thr Pro Thr Gly Ser
 195 200 205
 Cys Thr Gly Ser Gln Ala Leu Leu Leu Arg Ala Pro Tyr Ser Gly Gly
 210 215 220
 Asp Leu His Gln Thr Thr Ser Gln Leu Gly His Met Ala Trp Asn Gln
 225 230 240
 Thr Asn Leu Gly Ala Thr Leu Lys Gly His Gly Thr Gly Tyr Glu Ser
 245 250 255
 Asp Asp His Thr Thr Pro Ile Leu Cys Gly Thr Gln Tyr Arg Ile Arg
 260 265 270
 Ala Arg Gly Val Leu Arg Gly Thr Gln Asp Val Arg Cys Val Pro Gly
 275 280 285
 Val Ala Pro Thr Leu Val Arg Ser Ala Ser Glu Thr Ser Glu Lys Arg
 290 295 300
 Pro Leu Met Cys Ala Tyr Pro Gly Cys Asn Lys Arg His Phe Lys Pro
 305 310 315 320
 Ser Arg Leu Arg Val Arg Gly Arg Glu Arg Thr Gly Glu Lys Pro Tyr
 325 330 335
 Gln Arg Asp Phe Lys Asp Arg Gly Arg Gly Leu Leu Arg Pro Asp Gln
 340 345 350
 Leu Lys Arg His Gln Arg Gly His Thr Gly Val Lys Pro Leu Gln Cys
 355 360 365
 Glu Ala Arg Arg Arg Pro Pro Arg Pro Gly His Leu Lys Val His Thr
 370 375 380
 Arg Thr His Thr Gly Gly Glu Pro Phe Ser Cys Arg Trp Pro Ser Cys
 385 390 395 400
 Gln Glu Lys Ser Ala Arg Pro Asp Glu Ser Ala Arg Arg His Asn Met
 405 410 415
 His Gln Arg Asn Met Thr Lys Leu Gln Leu Ala Leu
 420 425

<210> 406

<211> 414

<212> PRT

<213> Homo sapiens

<220>

<221> VARIANT

<222> 85, 86, 172, 173, 242, 245, 246, 247

<223> Xaa = Any Amino Acid

<400> 406

Met Gly Ser Asp Val Arg Asp Leu Ser Ala Leu Leu Pro Ala Val Pro
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 Ser Leu Gly Asp Gly Gly Gly Cys Ala Leu Pro Val Ser Gly Ala Ala
 20 25 30
 Gln Trp Ala Pro Val Leu Asp Phe Ala Pro Pro Gly Ala Ser Ala His
 35 40 45
 Gly Pro Leu Gly Gly Pro Ala Pro Pro Ser Ala Pro Pro Pro Pro Pro
 50 55 60
 Pro Pro Pro Pro His Ser Phe Ile Lys Gln Gly Pro Ser Trp Gly Gly
 65 70 75 80

Ala Glu Leu His Xaa Xaa Gln Tyr Leu Ser Ala Phe Thr Val His Ser
 85 90 95
 Ser Gly Gln Val His Trp His Gly Arg Gly Leu Ser Leu Arg Ala Pro
 100 105 110
 Arg Pro Pro Ser Ala Gln Pro Gly Val Ile Arg Pro Gly Gln Asp Val
 115 120 125
 Ser Arg Ala Leu Pro Ala Gln Pro Pro Arg Glu Pro Ala Arg Tyr Pro
 130 135 140
 Gln Ser Gly Leu Gln His Gly His Leu Arg Arg Gly Val Arg Leu Arg
 145 150 155 160
 Ser His Ala Leu Ala Pro Cys Gly Ala Val Leu Xaa Xaa Thr Arg Ala
 165 170 175
 Gly Ser His Gly Pro Ala Gly Ser Ala Gly Ala Ala Val Leu Gly Ala
 180 185 190
 Ala Pro Gly Leu Trp Pro Pro His Pro Arg Arg Gln Leu Arg Arg Gln
 195 200 205
 Pro Gly Phe Ala Ala Glu Gly Ala Leu Gln Arg Arg Phe Ile Pro Ser
 210 215 220
 Asp Val Pro Ala Val His Gly Leu Glu Ser Asp Glu Pro Arg Gly Arg
 225 230 235 240
 Leu Xaa Gly Pro Xaa Xaa Xaa Val Arg Glu Arg Ser His Asn Ala Arg
 245 250 255
 Pro Leu Arg Ser Pro Ile Gln Asn Thr His Ala Arg Cys Leu Gln Gly
 260 265 270
 Arg Ser Gly Cys Ala Pro Cys Ala Trp Ser Ser Pro Asp Ser Cys Thr
 275 280 285
 Val Gly Ile Gly Gln Gly Thr Pro Pro His Val Cys Leu Pro Arg Leu
 290 295 300
 Gln Glu Val Ser Glu Ala Ala Pro Leu Thr Asp Ala Arg Glu Ala Arg
 305 310 315 320
 Trp Glu Thr Ile Pro Val Leu Gln Gly Leu Trp Thr Glu Val Phe Leu
 325 330 335
 Leu Arg Pro Ala Gln Lys Thr Pro Gly Glu Ala Tyr Arg Cys Glu Ala
 340 345 350
 Ile Pro Ala Asp Leu Ser Ala Arg Val Leu Pro Ala Gln Pro Pro Glu
 355 360 365
 Asp Pro Arg Gln Asp Ser Cys Arg Lys Ala Pro Gln Leu Ser Val Val
 370 375 380
 Arg Leu Ser Glu Lys Ala Cys Pro Val Lys Val Gly Pro Pro Ser Arg
 385 390 395 400
 His Ala Ser Glu Gly His Asp Arg Thr Pro Ala Gly Ala Leu
 405 410

<210> 407

<211> 417

<212> PRT

<213> Homo sapiens

<400> 407

Met Gly Ser Asp Val Arg Asp Leu Ser Ala Leu Leu Pro Thr Ala Pro
 1 5 10 15
 Ser Leu Gly Gly Gly Asp Cys Thr Leu Pro Val Ser Gly Thr Ala
 20 25 30
 Gln Trp Ala Pro Val Pro Ala Ser Ala Pro Pro Gly Ala Ser Ala Tyr
 35 40 45
 Asp Ser Leu Gly Gly Pro Ala Pro Pro Pro Ala Pro Pro Pro Pro Pro
 50 55 60

Pro Pro Pro Pro His Ser Cys Gly Glu Gln Gly Pro Ser Trp Gly Gly
 65 70 75 80
 Ala Glu Pro Arg Glu Gly Gln Cys Leu Ser Ala Pro Ala Val Arg Phe
 85 90 95
 Ser Gly Arg Phe Thr Gly Thr Val Gly Ala Cys Arg Tyr Gly Pro Leu
 100 105 110
 Gly Pro Pro Pro Pro Ser Gln Ala Pro Ser Gly Gln Thr Arg Met Leu
 115 120 125
 Pro Ser Ala Pro Tyr Leu Ser Ser Cys Leu Arg Ser Arg Ser Ala Ile
 130 135 140
 Arg Ser Gln Gly Arg Ser Thr Ala Pro Ser Ala Gly Arg Pro Ala Met
 145 150 155 160
 Ala Pro Thr Leu Ala Pro Pro Ala Gln Ser His Tyr Ser Gln His Gly
 165 170 175
 Val Leu His Gly Pro Ala Gly Leu Ala Gly Ala Val Leu Gly Ala
 180 185 190
 Ala Pro Gly Leu Trp Leu Pro His Arg Gln Leu His Arg Gln
 195 200 205
 Pro Gly Phe Ala Ala Glu Asp Ala Leu Gln Gln Phe Ile Pro Asn
 210 215 220
 Asp Ile Pro Ala Met His Asp Leu Glu Ser Asp Glu Leu Arg Ser His
 225 230 235 240
 Leu Lys Gly Pro Gln His Arg Val Arg Glu Arg Pro His Asn Ala His
 245 250 255
 Pro Leu Arg Ser Pro Ile Gln Asn Thr His Ala Arg Cys Leu Gln Arg
 260 265 270
 His Ser Gly Cys Ala Thr Cys Ala Trp Ser Ser Pro Asp Ser Cys Thr
 275 280 285
 Val Ala Pro Glu Thr Ser Glu Asn Ala Pro Trp Cys Val Leu Pro Gly
 290 295 300
 Leu Gln Gly Val Phe Ala Val Pro Leu Thr Gly Ala Gln Gln Glu Ala
 305 310 315 320
 His Trp Asp Ala Thr Pro Val Arg Leu Gln Gly Pro Trp Thr Arg Ala
 325 330 335
 Ser Pro Phe Gly Thr Ser Pro Arg Asp Thr Lys Gly Asp Ile Gln Val
 340 345 350
 Arg Asn His Ser Ser Val Arg Leu Val Ser Glu Gly Ser Pro Gly Pro
 355 360 365
 Thr Thr Gly Pro Thr Pro Gly Pro Thr Arg Val Gly Ser Pro Ser Ala
 370 375 380
 Ala Gly Gly Gln Ala Ala Arg Glu Gly Ser Pro Ser Gln Thr Asn Ser
 385 390 395 400
 Val Ile Thr Thr Cys Ile Ser Glu Thr Leu Asn Ser Ser Trp Arg Phe
 405 410 415
 Glu

<210> 408

<211> 429

<212> PRT

<213> Homo sapiens

<400> 408

Met Gly Ser Asp Val Arg Asp Leu Asn Ala Leu Leu Pro Ala Val Pro
 1 5 10 15
 Ser Leu Gly Gly Gly Gly Cys Ala Leu Pro Val Ser Gly Ala Ala
 20 25 30

Gln Trp Ala Pro Val Leu Asp Phe Ala Pro Pro Gly Ala Ser Ala Tyr
 35 40 45
 Gly Ser Leu Gly Gly Pro Ala Pro Pro Ala Pro Pro Pro Pro
 50 55 60
 Pro Pro Pro Pro His Ser Phe Ile Lys Gln Glu Pro Ser Trp Gly Gly
 65 70 75 80
 Ala Glu Pro His Glu Glu Gln Cys Leu Ser Ala Phe Thr Val His Phe
 85 90 95
 Ser Gly Gln Phe Thr Gly Thr Ala Gly Ala Cys Arg Tyr Gly Pro Phe
 100 105 110
 Gly Pro Pro Pro Pro Ser Gln Ala Ser Ser Gly Gln Ala Arg Met Phe
 115 120 125
 Pro Asn Ala Pro Tyr Leu Pro Ser Cys Leu Glu Ser Gln Pro Ala Ile
 130 135 140
 Arg Asn Gln Gly Tyr Ser Thr Val Thr Phe Asp Gly Thr Pro Ser Tyr
 145 150 155 160
 Gly His Thr Pro Ser His His Ala Ala Gln Phe Pro Asn His Ser Phe
 165 170 175
 Lys His Glu Asp Pro Met Gly Gln Gln Gly Ser Leu Gly Glu Gln Gln
 180 185 190
 Tyr Ser Val Pro Pro Pro Val Tyr Gly Cys His Thr Pro Thr Asp Ser
 195 200 205
 Cys Thr Gly Ser Gln Ala Leu Leu Leu Arg Thr Pro Tyr Ser Ser Asp
 210 215 220
 Asn Leu Tyr Gln Met Thr Ser Gln Leu Glu Cys Met Thr Trp Asn Gln
 225 230 235 240
 Met Asn Leu Gly Ala Thr Leu Lys Gly His Ser Thr Gly Tyr Glu Ser
 245 250 255
 Asp Asn His Thr Thr Pro Ile Leu Cys Gly Ala Gln Tyr Arg Ile His
 260 265 270
 Thr His Gly Val Phe Arg Gly Ile Gln Asp Val Arg Arg Val Pro Gly
 275 280 285
 Val Ala Pro Thr Leu Val Arg Ser Ala Ser Glu Thr Ser Glu Lys Arg
 290 295 300
 Pro Phe Met Cys Ala Tyr Pro Gly Cys Asn Lys Arg Tyr Phe Lys Leu
 305 310 315 320
 Ser His Leu Gln Met His Ser Arg Lys His Thr Gly Glu Lys Pro Tyr
 325 330 335
 Gln Cys Asp Phe Lys Asp Cys Glu Arg Arg Phe Phe Arg Ser Asp Gln
 340 345 350
 Leu Lys Arg His Gln Arg Arg His Thr Gly Val Lys Pro Phe Gln Cys
 355 360 365
 Lys Thr Cys Gln Arg Lys Phe Ser Arg Ser Asp His Leu Lys Thr His
 370 375 380
 Thr Arg Thr His Thr Gly Glu Lys Pro Phe Ser Cys Arg Trp Pro Ser
 385 390 395 400
 Cys Gln Lys Lys Phe Ala Arg Ser Asp Glu Leu Val Arg His His Asn
 405 410 415
 Met His Gln Arg Asn Met Thr Lys Leu Gln Leu Ala Leu
 420 425

<210> 409

<211> 495

<212> PRT

<213> Homo sapiens

<400> 409

Met Ala Ala Pro Gly Ala Arg Arg Ser Leu Leu Leu Leu Leu Ala
 1 5 10 15
 Gly Leu Ala His Gly Ala Ser Ala Leu Phe Glu Asp Leu Met Gly Ser
 20 25 30
 Asp Val Arg Asp Leu Asn Ala Leu Leu Pro Ala Val Pro Ser Leu Gly
 35 40 45
 Gly Gly Gly Gly Cys Ala Leu Pro Val Ser Gly Ala Ala Gln Trp Ala
 50 55 60
 Pro Val Leu Asp Phe Ala Pro Pro Gly Ala Ser Ala Tyr Gly Ser Leu
 65 70 75 80
 Gly Gly Pro Ala Pro Pro Ala Pro Pro Pro Pro Pro Pro His
 85 90 95
 Ser Phe Ile Lys Gln Glu Pro Ser Trp Gly Gly Ala Glu Pro His Glu
 100 105 110
 Glu Gln Cys Leu Ser Ala Phe Thr Val His Phe Ser Gly Gln Phe Thr
 115 120 125
 Gly Thr Ala Gly Ala Cys Arg Tyr Gly Pro Phe Gly Pro Pro Pro Pro
 130 135 140
 Ser Gln Ala Ser Ser Gly Gln Ala Arg Met Phe Pro Asn Ala Pro Tyr
 145 150 155
 Leu Pro Ser Cys Leu Glu Ser Gln Pro Ala Ile Arg Asn Gln Gly Tyr
 160 165 170 175
 Ser Thr Val Thr Phe Asp Gly Thr Pro Ser Tyr Gly His Thr Pro Ser
 180 185 190
 His His Ala Ala Gln Phe Pro Asn His Ser Phe Lys His Glu Asp Pro
 195 200 205
 Met Gly Gln Gln Gly Ser Leu Gly Glu Gln Gln Tyr Ser Val Pro Pro
 210 215 220
 Pro Val Tyr Gly Cys His Thr Pro Thr Asp Ser Cys Thr Gly Ser Gln
 225 230 235 240
 Ala Leu Leu Leu Arg Thr Pro Tyr Ser Ser Asp Asn Leu Tyr Gln Met
 245 250 255
 Thr Ser Gln Leu Glu Cys Met Thr Trp Asn Gln Met Asn Leu Gly Ala
 260 265 270
 Thr Leu Lys Gly His Ser Thr Gly Tyr Glu Ser Asp Asn His Thr Thr
 275 280 285
 Pro Ile Leu Cys Gly Ala Gln Tyr Arg Ile His Thr His Gly Val Phe
 290 295 300
 Arg Gly Ile Gln Asp Val Arg Arg Val Pro Gly Val Ala Pro Thr Leu
 305 310 315 320
 Val Arg Ser Ala Ser Glu Thr Ser Glu Lys Arg Pro Phe Met Cys Ala
 325 330 335
 Tyr Pro Gly Cys Asn Lys Arg Tyr Phe Lys Leu Ser His Leu Gln Met
 340 345 350
 His Ser Arg Lys His Thr Gly Glu Lys Pro Tyr Gln Cys Asp Phe Lys
 355 360 365
 Asp Cys Glu Arg Arg Phe Phe Arg Ser Asp Gln Leu Lys Arg His Gln
 370 375 380
 Arg Arg His Thr Gly Val Lys Pro Phe Gln Cys Lys Thr Cys Gln Arg
 385 390 395 400
 Lys Phe Ser Arg Ser Asp His Leu Lys Thr His Thr Arg Thr His Thr
 405 410 415
 Gly Glu Lys Pro Phe Ser Cys Arg Trp Pro Ser Cys Gln Lys Lys Phe
 420 425 430
 Ala Arg Ser Asp Glu Leu Val Arg His His Asn Met His Gln Arg Asn
 435 440 445
 Met Thr Lys Leu Gln Leu Ala Leu Leu Asn Asn Met Leu Ile Pro Ile
 450 455 460

Ala Val Gly Gly Ala Leu Ala Gly Leu Val Leu Ile Val Leu Ile Ala
 465 470 475 480
 Tyr Leu Ile Gly Arg Lys Arg Ser His Ala Gly Tyr Gln Thr Ile
 485 490 495

<210> 410
 <211> 504
 <212> PRT
 <213> Homo sapiens

<400> 410
 Met Gln Ile Phe Val Lys Thr Leu Thr Gly Lys Thr Ile Thr Leu Glu
 1 5 10 15
 Val Glu Pro Ser Asp Thr Ile Glu Asn Val Lys Ala Lys Ile Gln Asp
 20 25 30
 Lys Glu Gly Ile Pro Pro Asp Gln Gln Arg Leu Ile Phe Ala Gly Lys
 35 40 45
 Gln Leu Glu Asp Gly Arg Thr Leu Ser Asp Tyr Asn Ile Gln Lys Glu
 50 55 60
 Ser Thr Leu His Leu Val Leu Arg Leu Arg Gly Ala Met Gly Ser Asp
 65 70 75 80
 Val Arg Asp Leu Asn Ala Leu Leu Pro Ala Val Pro Ser Leu Gly Gly
 85 90 95
 Gly Gly Gly Cys Ala Leu Pro Val Ser Gly Ala Ala Gln Trp Ala Pro
 100 105 110
 Val Leu Asp Phe Ala Pro Pro Gly Ala Ser Ala Tyr Gly Ser Leu Gly
 115 120 125
 Gly Pro Ala Pro Pro Pro Ala Pro Pro Pro Pro Pro Pro His
 130 135 140
 Ser Phe Ile Lys Gln Glu Pro Ser Trp Gly Gly Ala Glu Pro His Glu
 145 150 155 160
 Glu Gln Cys Leu Ser Ala Phe Thr Val His Phe Ser Gly Gln Phe Thr
 165 170 175
 Gly Thr Ala Gly Ala Cys Arg Tyr Gly Pro Phe Gly Pro Pro Pro
 180 185 190
 Ser Gln Ala Ser Ser Gly Gln Ala Arg Met Phe Pro Asn Ala Pro Tyr
 195 200 205
 Leu Pro Ser Cys Leu Glu Ser Gln Pro Ala Ile Arg Asn Gln Gly Tyr
 210 215 220
 Ser Thr Val Thr Phe Asp Gly Thr Pro Ser Tyr Gly His Thr Pro Ser
 225 230 235 240
 His His Ala Ala Gln Phe Pro Asn His Ser Phe Lys His Glu Asp Pro
 245 250 255
 Met Gly Gln Gln Gly Ser Leu Gly Glu Gln Gln Tyr Ser Val Pro Pro
 260 265 270
 Pro Val Tyr Gly Cys His Thr Pro Thr Asp Ser Cys Thr Gly Ser Gln
 275 280 285
 Ala Leu Leu Leu Arg Thr Pro Tyr Ser Ser Asp Asn Leu Tyr Gln Met
 290 295 300
 Thr Ser Gln Leu Glu Cys Met Thr Trp Asn Gln Met Asn Leu Gly Ala
 305 310 315 320
 Thr Leu Lys Gly His Ser Thr Gly Tyr Glu Ser Asp Asn His Thr Thr
 325 330 335
 Pro Ile Leu Cys Gly Ala Gln Tyr Arg Ile His Thr His Gly Val Phe
 340 345 350
 Arg Gly Ile Gln Asp Val Arg Arg Val Pro Gly Val Ala Pro Thr Leu
 355 360 365

Val Arg Ser Ala Ser Glu Thr Ser Glu Lys Arg Pro Phe Met Cys Ala
 370 375 380
 Tyr Pro Gly Cys Asn Lys Arg Tyr Phe Lys Leu Ser His Leu Gln Met
 385 390 395 400
 His Ser Arg Lys His Thr Gly Glu Lys Pro Tyr Gln Cys Asp Phe Lys
 405 410 415
 Asp Cys Glu Arg Arg Phe Phe Arg Ser Asp Gln Leu Lys Arg His Gln
 420 425 430
 Arg Arg His Thr Gly Val Lys Pro Phe Gln Cys Lys Thr Cys Gln Arg
 435 440 445
 Lys Phe Ser Arg Ser Asp His Leu Lys Thr His Thr Arg Thr His Thr
 450 455 460
 Gly Glu Lys Pro Phe Ser Cys Arg Trp Pro Ser Cys Gln Lys Lys Phe
 465 470 475 480
 Ala Arg Ser Asp Glu Leu Val Arg His His Asn Met His Gln Arg Asn
 485 490 495
 Met Thr Lys Leu Gln Leu Ala Leu
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<210> 411
 <211> 10
 <212> PRT
 <213> Homo sapiens

<400> 411
 Val Leu Asp Phe Ala Pro Pro Gly Ala Ser
 1 5 10

<210> 412
 <211> 15
 <212> PRT
 <213> Homo sapiens

<400> 412
 Gln Trp Ala Pro Val Leu Asp Phe Ala Pro Pro Gly Ala Ser Ala
 1 5 10 15

<210> 413
 <211> 15
 <212> PRT
 <213> Homo sapiens

<400> 413
 Val Leu Asp Phe Ala Pro Pro Gly Ala Ser Ala Tyr Gly Ser Leu
 1 5 10 15

<210> 414
 <211> 9
 <212> PRT
 <213> Artificial Sequence

<220>
 <223> Synthetic peptide

<400> 414
Ile Leu Asp Phe Ala Pro Pro Gly Ala
1 5

<210> 415
<211> 9
<212> PRT
<213> Artificial Sequence

<220>
<223> Synthetic peptide

<400> 415
Leu Leu Asp Phe Ala Pro Pro Gly Ala
1 5

<210> 416
<211> 9
<212> PRT
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<220>
<223> Synthetic peptide

<400> 416
Phe Leu Asp Phe Ala Pro Pro Gly Ala
1 5

<210> 417
<211> 9
<212> PRT
<213> Artificial Sequence

<220>
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<400> 417
Lys Leu Asp Phe Ala Pro Pro Gly Ala
1 5

<210> 418
<211> 9
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<220>
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<400> 418
Met Leu Asp Phe Ala Pro Pro Gly Ala
1 5

<210> 419

<211> 9
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<213> Artificial Sequence

<220>
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<400> 419
Tyr Leu Asp Phe Ala Pro Pro Gly Ala
1 5

<210> 420
<211> 9
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<220>
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<400> 420
Val Met Asp Phe Ala Pro Pro Gly Ala
1 5

<210> 421
<211> 9
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<220>
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<400> 421
Val Leu Asp Glu Ala Pro Pro Gly Ala
1 5

<210> 422
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<220>
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<400> 422
Val Leu Asp Lys Ala Pro Pro Gly Ala
1 5

<210> 423
<211> 9
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<400> 423
Val Leu Asp Phe Ala Val Pro Gly Ala
1 5

<210> 424
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<400> 424
Val Leu Asp Phe Ala Pro Pro Lys Ala
1 5

<210> 425
<211> 9
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Val Leu Asp Phe Ala Pro Pro Gly Val
1 5

<210> 426
<211> 9
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<220>
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<400> 426
Val Leu Asp Phe Ala Pro Pro Gly Leu
1 5

<210> 427
<211> 9
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<400> 427
Phe Leu Asp Glu Ala Pro Pro Gly Ala
1 5

<210> 428
<211> 9
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<400> 428
Lys Leu Asp Glu Ala Pro Pro Gly Ala
1 5

<210> 429
<211> 9
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<400> 429
Tyr Leu Asp Glu Ala Pro Pro Gly Ala
1 5

<210> 430
<211> 9
<212> PRT
<213> Artificial Sequence

<220>
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<400> 430
Phe Leu Asp Lys Ala Pro Pro Gly Ala
1 5

<210> 431
<211> 9
<212> PRT
<213> Artificial Sequence

<220>
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<400> 431
Lys Leu Asp Lys Ala Pro Pro Gly Ala
1 5

<210> 432
<211> 9
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<213> Artificial Sequence

<220>

<223> Synthetic peptide

<400> 432

Tyr Leu Asp Lys Ala Pro Pro Gly Ala
1 5

<210> 433

<211> 9

<212> PRT

<213> Artificial Sequence

<220>

<223> Synthetic peptide

<400> 433

Phe Leu Asp Phe Ala Pro Pro Gly Val
1 5

<210> 434

<211> 9

<212> PRT

<213> Artificial Sequence

<220>

<223> Synthetic peptide

<400> 434

Lys Leu Asp Phe Ala Pro Pro Gly Val
1 5

<210> 435

<211> 9

<212> PRT

<213> Artificial Sequence

<220>

<223> Synthetic peptide

<400> 435

Tyr Leu Asp Phe Ala Pro Pro Gly Val
1 5

<210> 436

<211> 9

<212> PRT

<213> Artificial Sequence

<220>

<223> Synthetic peptide

<400> 436

Phe Leu Asp Phe Ala Pro Pro Gly Leu
1 5

100

<210> 437
<211> 9
<212> PRT
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<400> 437
Lys Leu Asp Phe Ala Pro Pro Gly Leu
1 5

<210> 438
<211> 9
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<400> 438
Tyr Leu Asp Phe Ala Pro Pro Gly Leu
1 5

<210> 439
<211> 9
<212> PRT
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<220>
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<400> 439
Phe Leu Asp Glu Ala Pro Pro Gly Val
1 5

<210> 440
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<220>
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<400> 440
Lys Leu Asp Glu Ala Pro Pro Gly Val
1 5

<210> 441
<211> 9
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<400> 441

Tyr Leu Asp Glu Ala Pro Pro Gly Val
1 5

<210> 442

<211> 9

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<213> Artificial Sequence

<220>

<223> Synthetic peptide

<400> 442

Phe Leu Asp Glu Ala Pro Pro Gly Leu
1 5

<210> 443

<211> 9

<212> PRT

<213> Artificial Sequence

<220>

<223> Synthetic peptide

<400> 443

Lys Leu Asp Glu Ala Pro Pro Gly Leu
1 5

<210> 444

<211> 9

<212> PRT

<213> Artificial Sequence

<220>

<223> Synthetic peptide

<400> 444

Tyr Leu Asp Glu Ala Pro Pro Gly Leu
1 5

<210> 445

<211> 9

<212> PRT

<213> Artificial Sequence

<220>

<223> Synthetic peptide

<400> 445

Val Leu Asp Phe Ala Gly Pro Gly Ala
1 5

<210> 446
<211> 9
<212> PRT
<213> Artificial Sequence

<220>
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<400> 446
Val Leu Asp Phe Ala Thr Pro Gly Ala
1 5

<210> 447
<211> 9
<212> PRT
<213> Artificial Sequence

<220>
<223> Synthetic peptide

<400> 447
Val Leu Asp Phe Ala Thr Pro Gly Val
1 5

<210> 448
<211> 9
<212> PRT
<213> Artificial Sequence

<220>
<223> Synthetic peptide

<400> 448
Val Leu Asp Phe Ala Thr Pro Gly Leu
1 5

<210> 449
<211> 9
<212> PRT
<213> Artificial Sequence

<220>
<223> Synthetic peptide

<400> 449
Val Leu Asp Phe Ala Thr Pro Gly Ser
1 5

<210> 450
<211> 9
<212> PRT
<213> Artificial Sequence

<220>

<223> Synthetic peptide

<400> 450

Val Leu Asp Phe Ala Thr Pro Gly Ala

1

5

<210> 451

<211> 9

<212> PRT

<213> Homo sapiens

<400> 451

Ala Leu Leu Pro Ala Val Pro Ser Leu

1

5

<210> 452

<211> 969

<212> DNA

<213> Homo sapiens

<400> 452

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acaggctccg	acgttcggga	cctgaacgca	ctgctgccgg	cagttccgtc	cctgggtggt	180
gggtggtggt	gcgcactgcc	ggttagcggt	gcagcacagt	gggtcccggt	cttggaattc	240
gcaccgcggg	gtgcatccgc	atacggttcc	ctgggtggtc	cggcacccgc	gcgggacacc	300
cgccgcggcg	cgccgcggcc	gcgcactccc	ttcatcaaac	aggaaccgag	ctggggtggt	360
gcagaaccgc	acgaagaaca	gtgcctgagc	gcattcaccg	ttcactttct	cggccagttc	420
actggcacag	ccggagccctg	tcgctacggg	cccttcggtc	ctcctccgcc	cagccaggcg	480
tcatccggcc	aggccaggat	gtttcctaac	gcgccctacc	tgcccagctg	cctcgagagc	540
cagcccgcta	ttcgcaatca	gggttacagc	acggtcacct	tcgacgggac	gccccagctac	600
gggtcacagc	cctgcaccca	tgccggcgag	ttccccaacc	actcattcaa	gcatgaggat	660
cccatcgccc	agcagggttc	gctgggtgag	cagcagtaact	cggtgccgcc	cccgtcttat	720
gggtcacagc	ccccaccaga	cagctgcacc	ggcagccagg	ctttgctgct	gaggaagccc	780
tacagcagtg	acaatttata	ccaaatgaca	tcccagctgt	aatgcatagc	ctggaattca	840
atgaacttag	gagccacttt	aaaggggcac	agcacagggt	acgagagcga	taaccacaca	900
acgccatccc	tctgcggagc	ccaatatcaga	atacacacgc	acgggtgtct	cagaggcatt	960
caqtgatga						969

<210> 453

<211> 1410

<212> DNA

<213> Homo sapiens

<400> 453

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ctgacctgtt	ctggtatgct	gggtccgtct	ctgctgacct	cgcgtcgtgc	taccgctgct	120
acaggctccg	acgttcggga	cctgaacgca	ctgctgccgg	cagttccgtc	cctgggtggt	180
gggtggtggt	gcgcactgcc	ggttagcggt	gcagcacagt	gggtcccggt	cttggaattc	240
gcaccgcggg	gtgcatccgc	atacggttcc	ctgggtggtc	cggcacccgc	gcgggacacc	300
cgccgcggcg	cgccgcggcc	gcgcactccc	ttcatcaaac	aggaaccgag	ctggggtggt	360
gcagaaccgc	acgaagaaca	gtgcctgagc	gcattcaccg	ttcactttct	cggccagttc	420
actggcacag	ccggagccctg	tcgctacggg	cccttcggtc	ctcctccgcc	cagccaggcg	480
tcatccggcc	aggccaggat	gtttcctaac	gcgccctacc	tgcccagctg	cctcgagagc	540
cagcccgcta	ttcgcaatca	gggttacagc	acggtcacct	tcgacgggac	gccccagctac	600

```

ggtcacacgc cctcgcacca tgcggcgagc ttccccaacc actcattcaa gcatgaggat 660
cccatggggc agcaggggctc gctgggtgag cagcagtact cgggtgccgc cccggtctat 720
ggctgccaca ccccccaccga cagctgcacc ggcagccagg ctttgctgct gaggacgcc 780
tacagcagtg acaatttata ccaaatgaca tcccagcttg aatgcatgac ctggaatcag 840
atgaacttag gagccacctt aaagggccac agcacagggt acgagagcga taaccacaca 900
acgcccattc tctcgggagc ccaatacaga atacacacgc acggtgtctt cagaggcatt 960
caggatgtgc gacgtgtgcc tggagtagcc ccgactcttg tacggtcggc atctgagacc 1020
agtgagaaac gccaccttcat gtgtgcttac ccagggtgca ataagagata ttttaagctg 1080
tcccacttac agatgcacag caggaagcac actggtgaga aaccatacca gtgtgacttc 1140
aaggactgtg aacgaaggtt ttttcgttca gaccagctca aaagacacca aaggagacat 1200
acaggtgtga aaccattcca gtgtaaaact tgtcagcgaa agttctcccg gtccgaccac 1260
ctgaagaccc acaccaggac tcatacaggt gaaaagccct tcagctgtcg gtggccaagt 1320
tgtcagaaaa agtttgcccg gtcagatgaa ttagtccgcc atcacaacat gcatcagaga 1380
aacatgacca aactccagct ggcgcttga 1410

```

<210> 454

<211> 469

<212> PRT

<213> Homo sapiens

<400> 454

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Met Asn Asn Asn Asp Leu Phe Gln Ala Ser Arg Arg Arg Phe Leu Ala
      5              10              15

```

```

Gln Leu Gly Gly Leu Thr Val Ala Gly Met Leu Gly Pro Ser Leu Leu
      20              25              30

```

```

Thr Pro Arg Arg Ala Thr Ala Ala His Gly Ser Asp Val Arg Asp Leu
      35              40              45

```

```

Asn Ala Leu Leu Pro Ala Val Pro Ser Leu Gly Gly Gly Gly Cys
      50              55              60

```

```

Ala Leu Pro Val Ser Gly Ala Ala Gln Trp Ala Pro Val Leu Asp Phe
      65              70              75              80

```

```

Ala Pro Pro Gly Ala Ser Ala Tyr Gly Ser Leu Gly Gly Pro Ala Pro
      85              90              95

```

```

Pro Pro Ala Pro Pro Pro Pro Pro Pro Pro Pro His Ser Phe Ile
      100             105             110

```

```

Lys Gln Glu Pro Ser Trp Gly Gly Ala Glu Pro His Glu Glu Gln Cys
      115             120             125

```

```

Leu Ser Ala Phe Thr Val His Phe Ser Gly Gln Phe Thr Gly Thr Ala
      130             135             140

```

```

Gly Ala Cys Arg Tyr Gly Pro Phe Gly Pro Pro Pro Ser Gln Ala
      145             150             155             160

```

```

Ser Ser Gly Gln Ala Arg Met Phe Pro Asn Ala Pro Tyr Leu Pro Ser
      165             170             175

```

```

Cys Leu Glu Ser Gln Pro Ala Ile Arg Asn Gln Gly Tyr Ser Thr Val
      180             185             190

```

```

Thr Phe Asp Gly Thr Pro Ser Tyr Gly His Thr Pro Ser His His Ala

```

195				200				205							
Ala	Gln	Phe	Pro	Asn	His	Ser	Phe	Lys	His	Glu	Asp	Pro	Met	Gly	Gln
210						215					220				
Gln	Gly	Ser	Leu	Gly	Glu	Gln	Gln	Tyr	Ser	Val	Pro	Pro	Pro	Val	Tyr
225						230				235					240
Gly	Cys	His	Thr	Pro	Thr	Asp	Ser	Cys	Thr	Gly	Ser	Gln	Ala	Leu	Leu
				245						250				255	
Leu	Arg	Thr	Pro	Tyr	Ser	Ser	Asp	Asn	Leu	Tyr	Gln	Met	Thr	Ser	Gln
			260							265				270	
Leu	Glu	Cys	Met	Thr	Trp	Asn	Gln	Met	Asn	Leu	Gly	Ala	Thr	Leu	Lys
			275				280								
Gly	His	Ser	Thr	Gly	Tyr	Glu	Ser	Asp	Asn	His	Thr	Thr	Pro	Ile	Leu
			290				295								
Cys	Gly	Ala	Gln	Tyr	Arg	Ile	His	Thr	His	Gly	Val	Phe	Arg	Gly	Ile
305						310				315					320
Gln	Asp	Val	Arg	Arg	Val	Pro	Gly	Val	Ala	Pro	Thr	Leu	Val	Arg	Ser
				325						330					
Ala	Ser	Glu	Thr	Ser	Glu	Lys	Arg	Pro	Phe	Met	Cys	Ala	Tyr	Pro	Gly
			340							345				350	
Cys	Asn	Lys	Arg	Tyr	Phe	Lys	Leu	Ser	His	Leu	Gln	Met	His	Ser	Arg
			355				360							365	
Lys	His	Thr	Gly	Glu	Lys	Pro	Tyr	Gln	Cys	Asp	Phe	Lys	Asp	Cys	Glu
			370				375								
Arg	Arg	Phe	Phe	Arg	Ser	Asp	Gln	Leu	Lys	Arg	His	Gln	Arg	Arg	His
385						390					395				400
Thr	Gly	Val	Lys	Pro	Phe	Gln	Cys	Lys	Thr	Cys	Gln	Arg	Lys	Phe	Ser
				405						410				415	
Arg	Ser	Asp	His	Leu	Lys	Thr	His	Thr	Arg	Thr	His	Thr	Gly	Glu	Lys
			420							425				430	
Pro	Phe	Ser	Cys	Arg	Trp	Pro	Ser	Cys	Gln	Lys	Lys	Phe	Ala	Arg	Ser
			435				440							445	
Asp	Glu	Leu	Val	Arg	His	Asn	Met	His	Gln	Arg	Asn	Met	Thr	Lys	
			450			455					460				
Leu	Gln	Leu	Ala	Leu											
465															

<210> 455

<211> 321

<212> PRT

<213> Homo sapiens

<400> 455

Met Asn Asn Asn Asp Leu Phe Gln Ala Ser Arg Arg Arg Phe Leu Ala
 5 10 15

Gln Leu Gly Gly Leu Thr Val Ala Gly Met Leu Gly Pro Ser Leu Leu
 20 25 30

Thr Pro Arg Arg Ala Thr Ala Ala His Gly Ser Asp Val Arg Asp Leu
 35 40 45

Asn Ala Leu Leu Pro Ala Val Pro Ser Leu Gly Gly Gly Gly Cys
 50 55 60

Ala Leu Pro Val Ser Gly Ala Ala Gln Trp Ala Pro Val Leu Asp Phe
 65 70 75 80

Ala Pro Pro Gly Ala Ser Ala Tyr Gly Ser Leu Gly Gly Pro Ala Pro
 85 90 95

Pro Pro Ala Pro Pro Pro Pro Pro Pro Pro Pro His Ser Phe Ile
 100 105 110

Lys Gln Glu Pro Ser Trp Gly Gly Ala Glu Pro His Glu Glu Gln Cys
 115 120 125

Leu Ser Ala Phe Thr Val His Phe Ser Gly Gln Phe Thr Gly Thr Ala
 130 135 140

Gly Ala Cys Arg Tyr Gly Pro Phe Gly Pro Pro Pro Pro Ser Gln Ala
 145 150 155 160

Ser Ser Gly Gln Ala Arg Met Phe Pro Asn Ala Pro Tyr Leu Pro Ser
 165 170 175

Cys Leu Glu Ser Gln Pro Ala Ile Arg Asn Gln Gly Tyr Ser Thr Val
 180 185 190

Thr Phe Asp Gly Thr Pro Ser Tyr Gly His Thr Pro Ser His His Ala
 195 200 205

Ala Gln Phe Pro Asn His Ser Phe Lys His Glu Asp Pro Met Gly Gln
 210 215 220

Gln Gly Ser Leu Gly Glu Gln Gln Tyr Ser Val Pro Pro Pro Val Tyr
 225 230 235 240

Gly Cys His Thr Pro Thr Asp Ser Cys Thr Gly Ser Gln Ala Leu Leu
 245 250 255

Leu Arg Thr Pro Tyr Ser Ser Asp Asn Leu Tyr Gln Met Thr Ser Gln
 260 265 270

Leu Glu Cys Met Thr Trp Asn Gln Met Asn Leu Gly Ala Thr Leu Lys
 275 280 285

Gly His Ser Thr Gly Tyr Glu Ser Asp Asn His Thr Thr Pro Ile Leu
 290 295 300

Cys Gly Ala Gln Tyr Arg Ile His Thr His Gly Val Phe Arg Gly Ile
 305 310 315 320

Gln

<210> 456
 <211> 24
 <212> DNA
 <213> Artificial Sequence

<220>
 <223> PCR primer

<400> 456
 ggctccgacg tgcgggacct gaac 24

<210> 457
 <211> 31
 <212> DNA
 <213> Artificial Sequence

<220>
 <223> PCR primer

<400> 457
 cgcgtgaatt catcaactgaa tgcctctgaa g 31

<210> 458
 <211> 21
 <212> DNA
 <213> Artificial Sequence

<220>
 <223> PCR primer

<400> 458
 ggctccgacg tgcgggacct g 21

<210> 459
 <211> 30
 <212> DNA
 <213> Artificial Sequence

<220>
 <223> PCR primer

<400> 459
 gaattctcaa agcgccagct ggagtttggt 30

<210> 460
 <211> 843
 <212> DNA
 <213> Homo sapiens

```

<400> 460
ggctccgacg ttcgggacct gaacgcactg ctgccggcag ttccgtccct ggggtggtgt 60
ggtggttgcg cactgcccgt tagcgggtgca gcacagtggg ctccggttct ggacttcgca 120
ccgcgcgggtg catccgdata cggttccctg ggtggtccgg caccgcccgc gccaccgccg 180
ccgcgcggcgc cgccgcggcc gcactccctc atcaaacagg aaccgagctg ggggtggtgca 240
gaaccgcagc aagaacagtg cctgagcgca ttcaccgttc acttctccgg ccagttcact 300
ggcacagccg gagcctgtcg ctacggggccc ctccgcccag ctccgcccag ccaggcgcta 360
tccggccagg ccaggatggt tcttaacgcg cctactctcg ccagctgctt cgagagccag 420
ccgcctattc gcaatcaggg ttacagcacg gtcactctcg acgggagccc cagctacggt 480
cacacgcctt cgcaccatgc ggcgcagttc cccaaccact cattcaagca tggagatccc 540
atggggccagc agggctcgct ggggtgagcag cagtactcgg tgccgccccg ggtctatggc 600
tgccacaccc ccaccgacag ctgcaccggc agccaggctt tgctgctgag gacgcccctac 660
agcagtgaaca atttatacca aatgacatcc cagcttgaat gcatacctg gaatcagatg 720
aacttaggag ccaccttaaa gggccacagc acaggggtac agagcgataa ccacacaacg 780
cccatcctct gcggagccca atacagaata cacacgcacg gtgtcttcag aggcattcag 840
tga

```

<210> 461

<211> 280

<212> PRT

<213> Homo sapiens

<400> 461

```

Gly Ser Asp Val Arg Asp Leu Asn Ala Leu Leu Pro Ala Val Pro Ser
1      5      10      15
Leu Gly Gly Gly Gly Cys Ala Leu Pro Val Ser Gly Ala Ala Gln
20     25     30
Trp Ala Pro Val Leu Asp Phe Ala Pro Pro Gly Ala Ser Ala Tyr Gly
35     40     45
Ser Leu Gly Gly Pro Ala Pro Pro Pro Ala Pro Pro Pro Pro Pro
50     55     60
Pro Pro Pro His Ser Phe Ile Lys Gln Glu Pro Ser Trp Gly Gly Ala
65     70     75     80
Glu Pro His Glu Glu Gln Cys Leu Ser Ala Phe Thr Val His Phe Ser
85     90     95
Gly Gln Phe Thr Gly Thr Ala Gly Ala Cys Arg Tyr Gly Pro Phe Gly
100    105    110
Pro Pro Pro Pro Ser Gln Ala Ser Ser Gly Gln Ala Arg Met Phe Pro
115    120    125
Asn Ala Pro Tyr Leu Pro Ser Cys Leu Glu Ser Gln Pro Ala Ile Arg
130    135    140
Asn Gln Gly Tyr Ser Thr Val Thr Phe Asp Gly Thr Pro Ser Tyr Gly
145    150    155    160
His Thr Pro Ser His His Ala Ala Gln Phe Pro Asn His Ser Phe Lys
165    170    175
His Glu Asp Pro Met Gly Gln Gln Gly Ser Leu Gly Glu Gln Gln Tyr
180    185    190
Ser Val Pro Pro Pro Val Tyr Gly Cys His Thr Pro Thr Asp Ser Cys
195    200    205
Thr Gly Ser Gln Ala Leu Leu Leu Arg Thr Pro Tyr Ser Ser Asp Asn
210    215    220
Leu Tyr Gln Met Thr Ser Gln Leu Glu Cys Met Thr Trp Asn Gln Met
225    230    235    240
Asn Leu Gly Ala Thr Leu Lys Gly His Ser Thr Gly Tyr Glu Ser Asp
245    250    255
Asn His Thr Thr Pro Ile Leu Cys Gly Ala Gln Tyr Arg Ile His Thr
260    265    270
His Gly Val Phe Arg Gly Ile Gln

```

109

275

280

<210> 462
 <211> 876
 <212> DNA
 <213> Homo sapiens

<400> 462
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 ggtggtggtt gcgcactgcc ggttagcggg gcagcacagt gggctccggg tctggaattc 120
 gcacgcgcgg gtgcatccgc atacggttcc ctgggtgggt cggcaccgcc gccggcaccg 180
 ccgcgcgcgc ccgcgcgcgc gccgcactcc ttcatacaac aggaaccgag ctgggtggtg 240
 gcagaaccgc acgaagaaca gtgcctgagc gcattcaccg ttactttctc cggccagttc 300
 actggcacag ccggagcctg tcgctacggg cccttcggtc ctctccgcc cagccaggcg 360
 tcatccggcc aggcaggagt gtttcttaac gcgccctacc tgcacgggac gccacgctac 420
 cagcccgcta ttgcgaatca gggttacagc acggtcacct tcgacgggac gccacgctac 480
 ggtcacacgc cctgcgacca tgcggcgagc ttcccaacc actcattcaa gcattgaggat 540
 cccatgggcc agcagggttc gctgggtgag cagcagttact cgggtgccgc cccggtctat 600
 ggctgccaca cccccaccga cagctgcacc ggcagccagg ctttctgctt gaggacgccc 660
 tacagcagtg acaatttata ccaaatgaca tccacgcttg aatgcatgac ctggaatcag 720
 atgaaacttag gagccacttt aaagggccac agcacagggt acgagagcga taaccacaca 780
 acgcccatacc tctgcggagc ccaatacaga atacacacgc acggtgtctt cagaggcatt 840
 cagcatcacc accatcatca tcaccatcac ctagg 876

<210> 463
 <211> 846
 <212> DNA
 <213> Homo sapiens

<400> 463
 atggggtccg acgtgcggga cctgaacgca ctgctgccgg cagttccgct cctgggtggt 60
 ggtggtggtt gcgcactgcc ggttagcggg gcagcacagt gggctccggg tctggaattc 120
 gcacgcgcgg gtgcatccgc atacggttcc ctgggtgggt cggcaccgcc gccggcaccg 180
 ccgcgcgcgc ccgcgcgcgc gccgcactcc ttcatacaac aggaaccgag ctgggtggtg 240
 gcagaaccgc acgaagaaca gtgcctgagc gcattcaccg ttactttctc cggccagttc 300
 actggcacag ccggagcctg tcgctacggg cccttcggtc ctctccgcc cagccaggcg 360
 tcatccggcc aggcaggagt gtttcttaac gcgccctacc tgcacgggac gccacgctac 420
 cagcccgcta ttgcgaatca gggttacagc acggtcacct tcgacgggac gccacgctac 480
 ggtcacacgc cctgcgacca tgcggcgagc ttcccaacc actcattcaa gcattgaggat 540
 cccatgggcc agcagggttc gctgggtgag cagcagttact cgggtgccgc cccggtctat 600
 ggctgccaca cccccaccga cagctgcacc ggcagccagg ctttctgctt gaggacgccc 660
 tacagcagtg acaatttata ccaaatgaca tccacgcttg aatgcatgac ctggaatcag 720
 atgaaacttag gagccacttt aaagggccac agcacagggt acgagagcga taaccacaca 780
 acgcccatacc tctgcggagc ccaatacaga atacacacgc acggtgtctt cagaggcatt 840
 cagtag 846

<210> 464
 <211> 291
 <212> PRT
 <213> Homo sapiens

<400> 464
 Met Gly Ser Asp Val Arg Asp Leu Asn Ala Leu Leu Pro Ala Val Pro
 5 10 15
 Ser Leu Gly Gly Gly Gly Cys Ala Leu Pro Val Ser Gly Ala Ala
 20 25 30

Gln Trp Ala Pro Val Leu Asp Phe Ala Pro Pro Gly Ala Ser Ala Tyr
 35 40 45
 Gly Ser Leu Gly Gly Pro Ala Pro Pro Pro Ala Pro Pro Pro Pro Pro
 50 55 60
 Pro Pro Pro Pro His Ser Phe Ile Lys Gln Glu Pro Ser Trp Gly Gly
 65 70 75 80
 Ala Glu Pro His Glu Glu Gln Cys Leu Ser Ala Phe Thr Val His Phe
 85 90 95
 Ser Gly Gln Phe Thr Gly Thr Ala Gly Ala Cys Arg Tyr Gly Pro Phe
 100 105 110
 Gly Pro Pro Pro Pro Ser Gln Ala Ser Ser Gly Gln Ala Arg Met Phe
 115 120 125
 Pro Asn Ala Pro Tyr Leu Pro Ser Cys Leu Glu Ser Gln Pro Ala Ile
 130 135 140
 Arg Asn Gln Gly Tyr Ser Thr Val Thr Phe Asp Gly Thr Pro Ser Tyr
 145 150 155 160
 Gly His Thr Pro Ser His His Ala Ala Gln Phe Pro Asn His Ser Phe
 165 170 175
 Lys His Glu Asp Pro Met Gly Gln Gln Gly Ser Leu Gly Glu Gln Gln
 180 185 190
 Tyr Ser Val Pro Pro Pro Val Tyr Gly Cys His Thr Pro Thr Asp Ser
 195 200 205
 Cys Thr Gly Ser Gln Ala Leu Leu Leu Arg Thr Pro Tyr Ser Ser Asp
 210 215 220
 Asn Leu Tyr Gln Met Thr Ser Gln Leu Glu Cys Met Thr Trp Asn Gln
 225 230 235 240
 Met Asn Leu Gly Ala Thr Leu Lys Gly His Ser Thr Gly Tyr Glu Ser
 245 250 255
 Asp Asn His Thr Thr Pro Ile Leu Cys Gly Ala Gln Tyr Arg Ile His
 260 265 270
 Thr His Gly Val Phe Arg Gly Ile Gln His His His His His His His
 275 280 285
 His His His
 290

<210> 465

<211> 281

<212> PRT

<213> Homo sapiens

111

<400> 465

Met Gly Ser Asp Val Arg Asp Leu Asn Ala Leu Leu Pro Ala Val Pro
 5 10 15

Ser Leu Gly Gly Gly Gly Gly Cys Ala Leu Pro Val Ser Gly Ala Ala
 20 25 30

Gln Trp Ala Pro Val Leu Asp Phe Ala Pro Pro Gly Ala Ser Ala Tyr
 35 40 45

Gly Ser Leu Gly Gly Pro Ala Pro Pro Pro Ala Pro Pro Pro Pro Pro
 50 55 60

Pro Pro Pro Pro His Ser Phe Ile Lys Gln Glu Pro Ser Trp Gly Gly
 65 70 75 80

Ala Glu Pro His Glu Glu Gln Cys Leu Ser Ala Phe Thr Val His Phe
 85 90 95

Ser Gly Gln Phe Thr Gly Thr Ala Gly Ala Cys Arg Tyr Gly Pro Phe
 100 105 110

Gly Pro Pro Pro Pro Ser Gln Ala Ser Ser Gly Gln Ala Arg Met Phe
 115 120 125

Pro Asn Ala Pro Tyr Leu Pro Ser Cys Leu Glu Ser Gln Pro Ala Ile
 130 135 140

Arg Asn Gln Gly Tyr Ser Thr Val Thr Phe Asp Gly Thr Pro Ser Tyr
 145 150 155 160

Gly His Thr Pro Ser His His Ala Ala Gln Phe Pro Asn His Ser Phe
 165 170 175

Lys His Glu Asp Pro Met Gly Gln Gln Gly Ser Leu Gly Glu Gln Gln
 180 185 190

Tyr Ser Val Pro Pro Pro Val Tyr Gly Cys His Thr Pro Thr Asp Ser
 195 200 205

Cys Thr Gly Ser Gln Ala Leu Leu Leu Arg Thr Pro Tyr Ser Ser Asp
 210 215 220

Asn Leu Tyr Gln Met Thr Ser Gln Leu Glu Cys Met Thr Trp Asn Gln
 225 230 235 240

Met Asn Leu Gly Ala Thr Leu Lys Gly His Ser Thr Gly Tyr Glu Ser
 245 250 255

Asp Asn His Thr Thr Pro Ile Leu Cys Gly Ala Gln Tyr Arg Ile His
 260 265 270

Thr His Gly Val Phe Arg Gly Ile Gln
 275 280

<210> 466

<211> 36

<212> DNA
 <213> Artificial Sequence

 <220>
 <223> PCR primer

 <400> 466
 cggtctctaga gccgccacca tgggtctcca cgtgcg 36

 <210> 467
 <211> 37
 <212> DNA
 <213> Artificial Sequence

 <220>
 <223> PCR primer

 <400> 467
 cggtctctaga ctactgaatg cctctgaaga caccgtg 37

 <210> 468
 <211> 67
 <212> DNA
 <213> Artificial Sequence

 <220>
 <223> PCR primer

 <400> 468
 cggtctctaga ctaattggtga tggatgatgat gatggtgatg atgctgaatg cctctgaaga 60
 caccgtg. 67

 <210> 469
 <211> 882
 <212> DNA
 <213> Homo sapiens

 <400> 469
 atgaacaata acgatctgtt tcaggcggag cgccacggct cgcaggttcg ggacctgaac 60
 gcaactgtctc cggcagttcc gtccctgggt ggtgggtggt gttgcgcact gccggttagc 120
 ggtgcagcac agtgggctcc ggttctggac ttgcgaccgc cgggtgcac cgcatacggc 180
 tccctggggtg gtccggcacc gccccggcca cgcgcggcgc gccgcggcac 240
 tccctcatca aacagggaacc gagctggggt ggtgcagaac cgcacgaaga acagtgcctg 300
 agcgcatcca cgttcaactt ctccggccag ttcaactggca cagccggagc ctgtcgctac 360
 gggcccttcg gtccctctcc gccagccag gcgtcatccg gccaggccag gatgtttctc 420
 aacgcggcct acctgccacc ctgcctcgag agccagccgc ctattcgcaa tcagggttac 480
 agcacggtca ccttcgacgg gacgccaccg tacggtcaca cgcctcgca ccatgcggcg 540
 cagttcccca accactcatt caagcatgag gatcccatgg gccagcaggg ctgcgtgggt 600
 gagcagcagt actcggctgc gcccccggtc tatggctgcc acacccccac cgacagctgc 660
 accggcagcc aggccttgcg gctgaggagc ccctacagca gtgacaattt ataccaaagt 720
 acatccacag ttgaatgcac gacctggaat cagatgaact taggagccac cttaaaggcg 780
 cacagcacag ggtacgagag cgataaccac acaacgcccc tcctctgcgg agcccaatca 840
 agaatacaca cgcacgggtg ctccagaggg attcagtgat ga 882

 <210> 470
 <211> 292
 <212> PRT

<213> Homo sapiens

<400> 470

Met Asn Asn Asn Asp Leu Phe Gln Ala Ser Arg His Gly Ser Asp Val
5 10 15

Arg Asp Leu Asn Ala Leu Leu Pro Ala Val Pro Ser Leu Gly Gly Gly
20 25 30

Gly Gly Cys Ala Leu Pro Val Ser Gly Ala Ala Gln Trp Ala Pro Val
35 40 45

Leu Asp Phe Ala Pro Pro Gly Ala Ser Ala Tyr Gly Ser Leu Gly Gly
50 55 60

Pro Ala Pro Pro Pro Ala Pro Pro Pro Pro Pro Pro Pro Pro His
65 70 75 80

Ser Phe Ile Lys Gln Glu Pro Ser Trp Gly Gly Ala Glu Pro His Glu
85 90 95

Glu Gln Cys Leu Ser Ala Phe Thr Val His Phe Ser Gly Gln Phe Thr
100 105 110

Gly Thr Ala Gly Ala Cys Arg Tyr Gly Pro Phe Gly Pro Pro Pro Pro
115 120 125

Ser Gln Ala Ser Ser Gly Gln Ala Arg Met Phe Pro Asn Ala Pro Tyr
130 135 140

Leu Pro Ser Cys Leu Glu Ser Gln Pro Ala Ile Arg Asn Gln Gly Tyr
145 150 155 160

Ser Thr Val Thr Phe Asp Gly Thr Pro Ser Tyr Gly His Thr Pro Ser
165 170 175

His His Ala Ala Gln Phe Pro Asn His Ser Phe Lys His Glu Asp Pro
180 185 190

Met Gly Gln Gln Gly Ser Leu Gly Glu Gln Gln Tyr Ser Val Pro Pro
195 200 205

Pro Val Tyr Gly Cys His Thr Pro Thr Asp Ser Cys Thr Gly Ser Gln
210 215 220

Ala Leu Leu Leu Arg Thr Pro Tyr Ser Ser Asp Asn Leu Tyr Gln Met
225 230 235 240

Thr Ser Gln Leu Glu Cys Met Thr Trp Asn Gln Met Asn Leu Gly Ala
245 250 255

Thr Leu Lys Gly His Ser Thr Gly Tyr Glu Ser Asp Asn His Thr Thr
260 265 270

Pro Ile Leu Cys Gly Ala Gln Tyr Arg Ile His Thr His Gly Val Phe
275 280 285

Arg Gly Ile Gln

290

<210> 471
 <211> 5315
 <212> DNA
 <213> E Coli

<400> 471

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ctttctcgcc	acgtttcgccg	gctttccccc	tcaagctcta	aatcgggggc	tccttttagg	180
gttcogattt	agtgtctttac	ggcacctcga	ccccaaaaaa	cttgattagg	gtgatggttc	240
acgtagtggg	ccatcgccctt	gatagacggt	ttttcgccct	ttgacgttgg	agtcacagtt	300
cttttaatagt	ggactcttgt	tcctaaactgg	aacacacact	aacctatctt	cggtctatcc	360
ttttgattta	taaggggattt	tgccgatttc	ggcctattgg	ttaaaaaaat	agctgattta	420
acaaaaattt	aacgcgaatt	ttacacaaat	attaacgttt	acaatttcag	gtggcaacttt	480
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tcgcgtcatg	aattaattct	tagaaaaact	catcgagcat	caaatgaaac	tgcaatttat	600
tcataatcagg	attatacaata	ccatattttt	gaaaaagccg	ttctgttaat	gaaggagaaa	660
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<210> 472

<211> 828

<212> DNA

<213> Homo sapiens

<400> 472

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<210> 473

<211> 811

<212> DNA

<213> Homo sapiens

<400> 473

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<210> 474

<211> 844

<212> DNA

<213> Homo sapiens

<400> 474

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<210> 475

<211> 927

<212> DNA

<213> Homo sapiens

<400> 475

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<210> 476

<211> 936

<212> DNA

<213> Homo sapiens

<400> 476

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<210> 477

<211> 969

<212> DNA

<213> Homo sapiens

<400> 477

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<210> 478
<211> 267
<212> PRT
<213> Homo sapiens
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<210> 479

<211> 321

<212> PRT

<213> Homo sapiens

<400> 479

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Thr Pro Arg Arg Ala Thr Ala Ala His Gly Ser Asp Val Arg Asp Leu
 35 40 45

Asn Ala Leu Leu Pro Ala Val Pro Ser Leu Gly Gly Gly Gly Cys
 50 55 60

Ala Leu Pro Val Ser Gly Ala Ala Gln Trp Ala Pro Val Leu Asp Phe
 65 70 75 80

Ala Pro Pro Gly Ala Ser Ala Tyr Gly Ser Leu Gly Gly Pro Ala Pro
 85 90 95

Pro Pro Ala Pro Pro Pro Pro Pro Pro Pro His Ser Phe Ile
 100 105 110

Lys Gln Glu Pro Ser Trp Gly Gly Ala Glu Pro His Glu Glu Gln Cys
 115 120 125

Leu Ser Ala Phe Thr Val His Phe Ser Gly Gln Phe Thr Gly Thr Ala
 130 135 140

Gly Ala Cys Arg Tyr Gly Pro Phe Gly Pro Pro Pro Ser Gln Ala
 145 150 155 160

Ser Ser Gly Gln Ala Arg Met Phe Pro Asn Ala Pro Tyr Leu Pro Ser
 165 170 175

Cys Leu Glu Ser Gln Pro Ala Ile Arg Asn Gln Gly Tyr Ser Thr Val
 180 185 190

Thr Phe Asp Gly Thr Pro Ser Tyr Gly His Thr Pro Ser His His Ala
 195 200 205

Ala Gln Phe Pro Asn His Ser Phe Lys His Glu Asp Pro Met Gly Gln
 210 215 220

Gln Gly Ser Leu Gly Glu Gln Gln Tyr Ser Val Pro Pro Pro Val Tyr
 225 230 235 240

Gly Cys His Thr Pro Thr Asp Ser Cys Thr Gly Ser Gln Ala Leu Leu
 245 250 255

120

Leu Arg Thr Pro Tyr Ser Ser Asp Asn Leu Tyr Gln Met Thr Ser Gln
260 265 270

Leu Glu Cys Met Thr Trp Asn Gln Met Asn Leu Gly Ala Thr Leu Lys
275 280 285

Gly His Ser Thr Gly Tyr Glu Ser Asp Asn His Thr Thr Pro Ile Leu
290 295 300

Cys Gly Ala Gln Tyr Arg Ile His Thr His Gly Val Phe Arg Gly Ile
305 310 315 320

Gln

<210> 480

<211> 274

<212> PRT

<213> Homo sapiens

<400> 480

Met Gln His His His His His His Gly Ser Asp Val Arg Asp Leu Asn
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Ala Leu Leu Pro Ala Val Pro Ser Leu Gly Gly Gly Gly Gly Cys Ala
20 25 30

Leu Pro Val Ser Gly Ala Ala Gln Trp Ala Pro Val Leu Asp Phe Ala
35 40 45

Pro Pro Gly Ala Ser Ala Tyr Gly Ser Leu Gly Gly Pro His Ser Phe
50 55 60

Ile Lys Gln Glu Pro Ser Trp Gly Gly Ala Glu Pro His Glu Glu Gln
65 70 75 80

Cys Leu Ser Ala Phe Thr Val His Phe Ser Gly Gln Phe Thr Gly Thr
85 90 95

Ala Gly Ala Cys Arg Tyr Gly Pro Phe Gly Pro Pro Pro Ser Gln
100 105 110

Ala Ser Ser Gly Gln Ala Arg Met Phe Pro Asn Ala Pro Tyr Leu Pro
115 120 125

Ser Cys Leu Glu Ser Gln Pro Ala Ile Arg Asn Gln Gly Tyr Ser Thr
130 135 140

Val Thr Phe Asp Gly Thr Pro Ser Tyr Gly His Thr Pro Ser His His
145 150 155 160

Ala Ala Gln Phe Pro Asn His Ser Phe Lys His Glu Asp Pro Met Gly
165 170 175

Gln Gln Gly Ser Leu Gly Glu Gln Gln Tyr Ser Val Pro Pro Pro Val
180 185 190

121

Tyr Gly Cys His Thr Pro Thr Asp Ser Cys Thr Gly Ser Gln Ala Leu
195 200 205

Leu Leu Arg Thr Pro Tyr Ser Ser Asp Asn Leu Tyr Gln Met Thr Ser
210 215 220

Gln Leu Glu Cys Met Thr Trp Asn Gln Met Asn Leu Gly Ala Thr Leu
225 230 235 240

Lys Gly His Ser Thr Gly Tyr Glu Ser Asp Asn His Thr Thr Pro Ile
245 250 255

Leu Cys Gly Ala Gln Tyr Arg Ile His Thr His Gly Val Phe Arg Gly
260 265 270

Ile Gln

<210> 481

<211> 310

<212> PRT

<213> Homo sapiens

<400> 481

Met Asn Asn Asn Asp Leu Phe Gln Ala Ser Arg Arg Arg Phe Leu Ala
5 10 15

Gln Leu Gly Gly Leu Thr Val Ala Gly Met Leu Gly Pro Ser Leu Leu
20 25 30

Thr Pro Arg Arg Ala Thr Ala Ala His Gly Ser Asp Val Arg Asp Leu
35 40 45

Asn Ala Leu Leu Pro Ala Val Pro Ser Leu Gly Gly Gly Gly Cys
50 55 60

Ala Leu Pro Val Ser Gly Ala Ala Gln Trp Ala Pro Val Leu Asp Phe
65 70 75 80

Ala Pro Pro Gly Ala Ser Ala Tyr Gly Ser Leu Gly Gly Pro Gly Gln
85 90 95

Ile His Ser Phe Ile Lys Gln Glu Pro Ser Trp Gly Gly Ala Glu Pro
100 105 110

His Glu Glu Gln Cys Leu Ser Ala Phe Thr Val His Phe Ser Gly Gln
115 120 125

Phe Thr Gly Thr Ala Gly Ala Cys Arg Tyr Gly Pro Phe Gly Pro Pro
130 135 140

Pro Pro Ser Gln Ala Ser Ser Gly Gln Ala Arg Met Phe Pro Asn Ala
145 150 155 160

Pro Tyr Leu Pro Ser Cys Leu Glu Ser Gln Pro Ala Ile Arg Asn Gln
165 170 175

122

Gly Tyr Ser Thr Val Thr Phe Asp Gly Thr Pro Ser Tyr Gly His Thr
 180 185 190
 Pro Ser His His Ala Ala Gln Phe Pro Asn His Ser Phe Lys His Glu
 195 200 205
 Asp Pro Met Gly Gln Gln Gly Ser Leu Gly Glu Gln Gln Tyr Ser Val
 210 215 220
 Pro Pro Pro Val Tyr Gly Cys His Thr Pro Thr Asp Ser Cys Thr Gly
 225 230 235 240
 Ser Gln Ala Leu Leu Leu Arg Thr Pro Tyr Ser Ser Asp Asn Leu Tyr
 245 250 255
 Gln Met Thr Ser Gln Leu Glu Cys Met Thr Trp Asn Gln Met Asn Leu
 260 265 270
 Gly Ala Thr Leu Lys Gly His Ser Thr Gly Tyr Glu Ser Asp Asn His
 275 280 285
 Thr Thr Pro Ile Leu Cys Gly Ala Gln Tyr Arg Ile His Thr His Gly
 290 295 300
 Val Phe Arg Gly Ile Gln
 305 310

<210> 482

<211> 307

<212> PRT

<213> Homo sapiens

<400> 482

Met Asn Asn Asn Asp Leu Phe Gln Ala Ser Arg Arg Arg Phe Leu Ala
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 Gln Leu Gly Gly Leu Thr Val Ala Gly Met Leu Gly Pro Ser Leu Leu
 20 25 30
 Thr Pro Arg Arg Ala Thr Ala Ala His Gly Ser Asp Val Arg Asp Leu
 35 40 45
 Asn Ala Leu Leu Pro Ala Val Pro Ser Leu Gly Gly Gly Gly Cys
 50 55 60
 Ala Leu Pro Val Ser Gly Ala Ala Gln Trp Ala Pro Val Leu Asp Phe
 65 70 75 80
 Ala Pro Pro Gly Ala Ser Ala Tyr Gly Ser Leu Gly Gly Pro His Ser
 85 90 95
 Phe Ile Lys Gln Glu Pro Ser Trp Gly Gly Ala Glu Pro His Glu Gly
 100 105 110
 Gln Cys Leu Ser Ala Phe Thr Val His Phe Ser Gly Gln Phe Thr Gly
 115 120 125

Thr Ala Gly Ala Cys Arg Tyr Gly Pro Phe Gly Pro Pro Pro Pro Ser
 130 135 140
 Gln Ala Ser Ser Gly Gln Ala Arg Met Phe Pro Asn Ala Pro Tyr Leu
 145 150 155 160
 Pro Ser Cys Leu Glu Ser Gln Pro Ala Ile Arg Asn Gln Gly Tyr Ser
 165 170 175
 Thr Val Thr Phe Asp Gly Thr Pro Ser Tyr Gly His Thr Pro Ser His
 180 185 190
 His Ala Ala Gln Phe Pro Asn His Ser Phe Lys His Glu Asp Pro Met
 195 200 205
 Gly Gln Gln Gly Ser Leu Gly Glu Gln Gln Tyr Ser Val Pro Pro Pro
 210 215 220
 Val Tyr Gly Cys His Thr Pro Thr Asp Ser Cys Thr Gly Ser Gln Ala
 225 230 235 240
 Leu Leu Leu Arg Thr Pro Tyr Ser Ser Asp Asn Leu Tyr Gln Met Thr
 245 250 255
 Ser Gln Leu Glu Cys Met Thr Trp Asn Gln Met Asn Leu Gly Ala Thr
 260 265 270
 Leu Lys Gly His Ser Thr Gly Tyr Glu Ser Asp Asn His Thr Thr Pro
 275 280 285
 Ile Leu Cys Gly Ala Gln Tyr Arg Ile His Thr His Gly Val Phe Arg
 290 295 300
 Gly Ile Gln
 305

<210> 483

<211> 278

<212> FRT

<213> Homo sapiens

<400> 483

Met Asn Asn Asn Asp Leu Phe Gln Ala Ser Arg His Gly Ser Asp Val
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 Arg Asp Leu Asn Ala Leu Leu Pro Ala Val Pro Ser Leu Gly Gly Gly
 20 25 30
 Gly Gly Cys Ala Leu Pro Val Ser Gly Ala Ala Gln Trp Ala Pro Val
 35 40 45
 Leu Asp Phe Ala Pro Pro Gly Ala Ser Ala Tyr Gly Ser Leu Gly Gly
 50 55 60
 Pro His Ser Phe Ile Lys Gln Glu Pro Ser Trp Gly Gly Ala Glu Pro
 65 70 75 80

124

His Glu Glu Gln Cys Leu Ser Ala Phe Thr Val His Phe Ser Gly Gln
 85 90 95
 Phe Thr Gly Thr Ala Gly Ala Cys Arg Tyr Gly Pro Phe Gly Pro Pro
 100 105 110
 Pro Pro Ser Gln Ala Ser Ser Gly Gln Ala Arg Met Phe Pro Asn Ala
 115 120 125
 Pro Tyr Leu Pro Ser Cys Leu Glu Ser Gln Pro Ala Ile Arg Asn Gln
 130 135 140
 Gly Tyr Ser Thr Val Thr Phe Asp Gly Thr Pro Ser Tyr Gly His Thr
 145 150 155 160
 Pro Ser His His Ala Ala Gln Phe Pro Asn His Ser Phe Lys His Glu
 165 170 175
 Asp Pro Met Gly Gln Gln Gly Ser Leu Gly Glu Gln Gln Tyr Ser Val
 180 185 190
 Pro Pro Pro Val Tyr Gly Cys His Thr Pro Thr Asp Ser Cys Thr Gly
 195 200 205
 Ser Gln Ala Leu Leu Leu Arg Thr Pro Tyr Ser Ser Asp Asn Leu Tyr
 210 215 220
 Gln Met Thr Ser Gln Leu Glu Cys Met Thr Trp Asn Gln Met Asn Leu
 225 230 235 240
 Gly Ala Thr Leu Lys Gly His Ser Thr Gly Tyr Glu Ser Asp Asn His
 245 250 255
 Thr Thr Pro Ile Leu Cys Gly Ala Gln Tyr Arg Ile His Thr His Gly
 260 265 270
 Val Phe Arg Gly Ile Gln
 275

<210> 484
 <211> 30
 <212> DNA
 <213> Artificial Sequence

<220>
 <223> PCR primer

<400> 484
 ggctccgacg ttcgggacct gaacgcactg

30

<210> 485
 <211> 31
 <212> DNA
 <213> Artificial Sequence
 <220>

<223> PCR primer

<400> 485

ctgcagaatt catcactgaa tgcctctgaa g

31

<210> 486

<211> 27

<212> DNA

<213> Artificial Sequence

<220>

<223> Oligonucleotide used in construction of the TAT
"Stumpy" vector.

<400> 486

tatgaacaat aacgatctgt ttcaggc

27

<210> 487

<211> 23

<212> DNA

<213> Artificial Sequence

<220>

<223> Oligonucleotide used in construction of the TAT
"Stumpy" vector.

<400> 487

ctgaacaga tcgttattgt tca

23

<210> 488

<211> 29

<212> DNA

<213> Artificial Sequence

<220>

<223> Oligonucleotide used in construction of the TAT
"Stumpy" vector.

<400> 488

aattcttggt cattcacgtg gcggtcgc

29

<210> 489

<211> 23

<212> DNA

<213> Artificial Sequence

<220>

<223> Oligonucleotide used in construction of the TAT
"Stumpy" vector.

<400> 489

gagccgccac gtgaatgacc aag

23

<210> 490

<211> 31

<212> DNA

<213> Artificial Sequence

<220>
<223> PCR primer

<400> 490
caagcgctca tgagcccgaa gtggcgagcc c 31

<210> 491
<211> 32
<212> DNA
<213> Artificial Sequence

<220>
<223> PCR primer

<400> 491
cataaatttg cccgggcccgcg ccagagagc cg 32

<210> 492
<211> 23
<212> DNA
<213> Artificial Sequence

<220>
<223> PCR primer

<400> 492
cattcattca tcaaacagga gcc 23

<210> 493
<211> 26
<212> DNA
<213> Artificial Sequence

<220>
<223> PCR primer

<400> 493
ccattaagaa ttcacatctg aatacc 26

<210> 494
<211> 25
<212> DNA
<213> Artificial Sequence

<220>
<223> PCR primer

<400> 494
ggttcggatg tacgcgatct gaacg 25

<210> 495
<211> 26
<212> DNA
<213> Artificial Sequence

<220>
<223> PCR primer

127

<400> 495
 caaagaattc atcactgaat accgcg 26

 <210> 496
 <211> 33
 <212> DNA
 <213> Artificial Sequence

 <220>
 <223> PCR primer

 <400> 496
 gcttttggca tatgggtctcg gatgtacgcg atc 33

 <210> 497
 <211> 26
 <212> DNA
 <213> Artificial Sequence

 <220>
 <223> PCR primer

 <400> 497
 caaagaattc atcactgaat accgcg 26

 <210> 498
 <211> 882
 <212> DNA
 <213> Homo sapiens

 <400> 498
 atgaacaata acgatctgtt tcaggcgcgc cggcaccggt cggatgtacg ccatctgaac 60
 gcgctttctt cgcgcgttccc aagcttgggc gggggagggt gatgcgcctt gcccgtagcg 120
 ggcgcgcgcg aatgggcccc ggtccttgat ttgtctccgc cgggtgcgcg cgcatacggc 180
 tctctggggc gtcgcgcacc tcctccagca ccgcctccac cgcaccgcgc gccgcgcgat 240
 tcattcatca aacaggagcc cagctgggggt ggccgcgaac ctcatgaaga acaatgctcg 300
 tctgctttta cegtacattt ttccaggccag ttaccgggaa ctgccggtgc atgtcgtcat 360
 ggcccatctc gtcgcgcgcc accgtcacaa gcctcttcgg gacaagcccg catgtttccg 420
 aatgcaccct acctgcgcgc ttgtctggaa agccaaaccg cgatccgtaa ccaaggctac 480
 agcacccgtca cgtttgatgg taaccgcgagc tatggtcata cgcgcgagtc tcatgcagca 540
 cagttcccca accactcgtt caaacacgaa gatcctatgg gccagcaggg tagtctgggc 600
 gaacaacagt atagcgtccc accaccagtt tatggttgcc ataccccaac ggattcctgt 660
 actggtagcc aagcgtcctt gctccgcacc cctattctt ctgataatct ctatcagatg 720
 accagccaac tggaatgtat gacgtggaac caaatgaacc tggcgccaac cctgaaaggc 780
 cacagtaccg gctatgagtc agataaccac acaacacca tttgtgcgg cgctcaatat 840
 cgtattcata cccatggcgt ttttcgcggt attcagtgat ga 882

 <210> 499
 <211> 292
 <212> PRT
 <213> Homo sapiens

 <400> 499
 Met Asn Asn Asn Asp Leu Phe Gln Ala Ser Arg His Gly Ser Asp Val
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 Arg Asp Leu Asn Ala Leu Leu Pro Ala Val Pro Ser Leu Gly Gly Gly
 20 25 30

128

Gly Gly Cys Ala Leu Pro Val Ser Gly Ala Ala Gln Trp Ala Pro Val
 35 40 45
 Leu Asp Phe Ala Pro Pro Gly Ala Ser Ala Tyr Gly Ser Leu Gly Gly
 50 55 60
 Pro Ala Pro Pro Pro Ala Pro Pro Pro Pro Pro Pro Pro Pro His
 65 70 75 80
 Ser Phe Ile Lys Gln Glu Pro Ser Trp Gly Gly Ala Glu Pro His Glu
 85 90 95
 Glu Gln Cys Leu Ser Ala Phe Thr Val His Phe Ser Gly Gln Phe Thr
 100 105 110
 Gly Thr Ala Gly Ala Cys Arg Tyr Gly Pro Phe Gly Pro Pro Pro Pro
 115 120 125
 Ser Gln Ala Ser Ser Gly Gln Ala Arg Met Phe Pro Asn Ala Pro Tyr
 130 135 140
 Leu Pro Ser Cys Leu Glu Ser Gln Pro Ala Ile Arg Asn Gln Gly Tyr
 145 150 155 160
 Ser Thr Val Thr Phe Asp Gly Thr Pro Ser Tyr Gly His Thr Pro Ser
 165 170 175
 His His Ala Ala Gln Phe Pro Asn His Ser Phe Lys His Glu Asp Pro
 180 185 190
 Met Gly Gln Gln Gly Ser Leu Gly Glu Gln Gln Tyr Ser Val Pro Pro
 195 200 205
 Pro Val Tyr Gly Cys His Thr Pro Thr Asp Ser Cys Thr Gly Ser Gln
 210 215 220
 Ala Leu Leu Leu Arg Thr Pro Tyr Ser Ser Asp Asn Leu Tyr Gln Met
 225 230 235 240
 Thr Ser Gln Leu Glu Cys Met Thr Trp Asn Gln Met Asn Leu Gly Ala
 245 250 255
 Thr Leu Lys Gly His Ser Thr Gly Tyr Glu Ser Asp Asn His Thr Thr
 260 265 270
 Pro Ile Leu Cys Gly Ala Gln Tyr Arg Ile His Thr His Gly Val Phe
 275 280 285
 Arg Gly Ile Gln
 290

<210> 500

<211> 25

<212> DNA

<213> Artificial Sequence

<220>

<223> PCR primer

<400> 500

ggttcggatg tacgcgatct gaacg

25

<210> 501

<211> 26

<212> DNA

<213> Artificial Sequence

<220>

<223> PCR primer

<400> 501

caaagaattc atcactgaat accgcg

26

<210> 502

<211> 270

<212> PRT

<213> Homo sapiens

<400> 502

Met Gly Ser Asp Val Arg Asp Leu Asn Ala Leu Leu Pro Ala Val Pro
 1 5 10 15
 Ser Leu Gly Gly Gly Gly Cys Ala Leu Pro Val Ser Gly Ala Ala
 20 25 30
 Gln Trp Ala Pro Val Leu Asp Phe Ala Pro Pro Gly Ala Ser Ala Tyr
 35 40 45
 Gly Ser Leu Gly Gly Pro Gly Gln Ile His Ser Phe Ile Lys Gln Glu
 50 55 60
 Pro Ser Trp Gly Gly Ala Glu Pro His Glu Glu Gln Cys Leu Ser Ala
 65 70 75 80
 Phe Thr Val His Phe Ser Gly Gln Phe Thr Gly Thr Ala Gly Ala Cys
 85 90 95
 Arg Tyr Gly Pro Phe Gly Pro Pro Pro Ser Ser Gln Ala Ser Ser Gly
 100 105 110
 Gln Ala Arg Met Phe Pro Asn Ala Pro Tyr Leu Pro Ser Cys Leu Glu
 115 120 125
 Ser Gln Pro Ala Ile Arg Asn Gln Gly Tyr Ser Thr Val Thr Phe Asp
 130 135 140
 Gly Thr Pro Ser Tyr Gly His Thr Pro Ser His His Ala Ala Gln Phe
 145 150 155 160
 Pro Asn His Ser Phe Lys His Glu Asp Pro Met Gly Gln Gln Gly Ser
 165 170 175
 Leu Gly Glu Gln Gln Tyr Ser Val Pro Pro Val Tyr Gly Cys His
 180 185 190
 Thr Pro Thr Asp Ser Cys Thr Gly Ser Gln Ala Leu Leu Leu Arg Thr
 195 200 205
 Pro Tyr Ser Ser Asp Asn Leu Tyr Gln Met Thr Ser Gln Leu Glu Cys
 210 215 220
 Met Thr Trp Asn Gln Met Asn Leu Gly Ala Thr Leu Lys Gly His Ser
 225 230 235 240
 Thr Gly Tyr Glu Ser Asp Asn His Thr Thr Pro Ile Leu Cys Gly Ala
 245 250 255
 Gln Tyr Arg Ile His Thr His Gly Val Phe Arg Gly Ile Gln
 260 265 270

130

<210> 503
 <211> 5400
 <212> DNA
 <213> E. coli

<400> 503

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